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ABSTRACT

Background papers are supplied that outline the energy education needs for New Jersey schools and show the dimensions of the energy crisis in terms of the availability of fuel sources. A curriculum model for Introduction to Energy and Energy Conservation is supplied with background information written for all teachers from kindergarten through secondary school. Four teaching units provide for the differentiation of instruction: kindergarten-primary, upper elementary, middle school, and high school level. A glossary and an extensive bibliography complete the model. The major goal of the publication is to give the teacher orientation to energy education and the encouragement to do research and teaching beyond the initial, condensed content. Another section describes energy audits for school buildings as well as suggesting guidelines for starting a district energy program. (Author/MLF)

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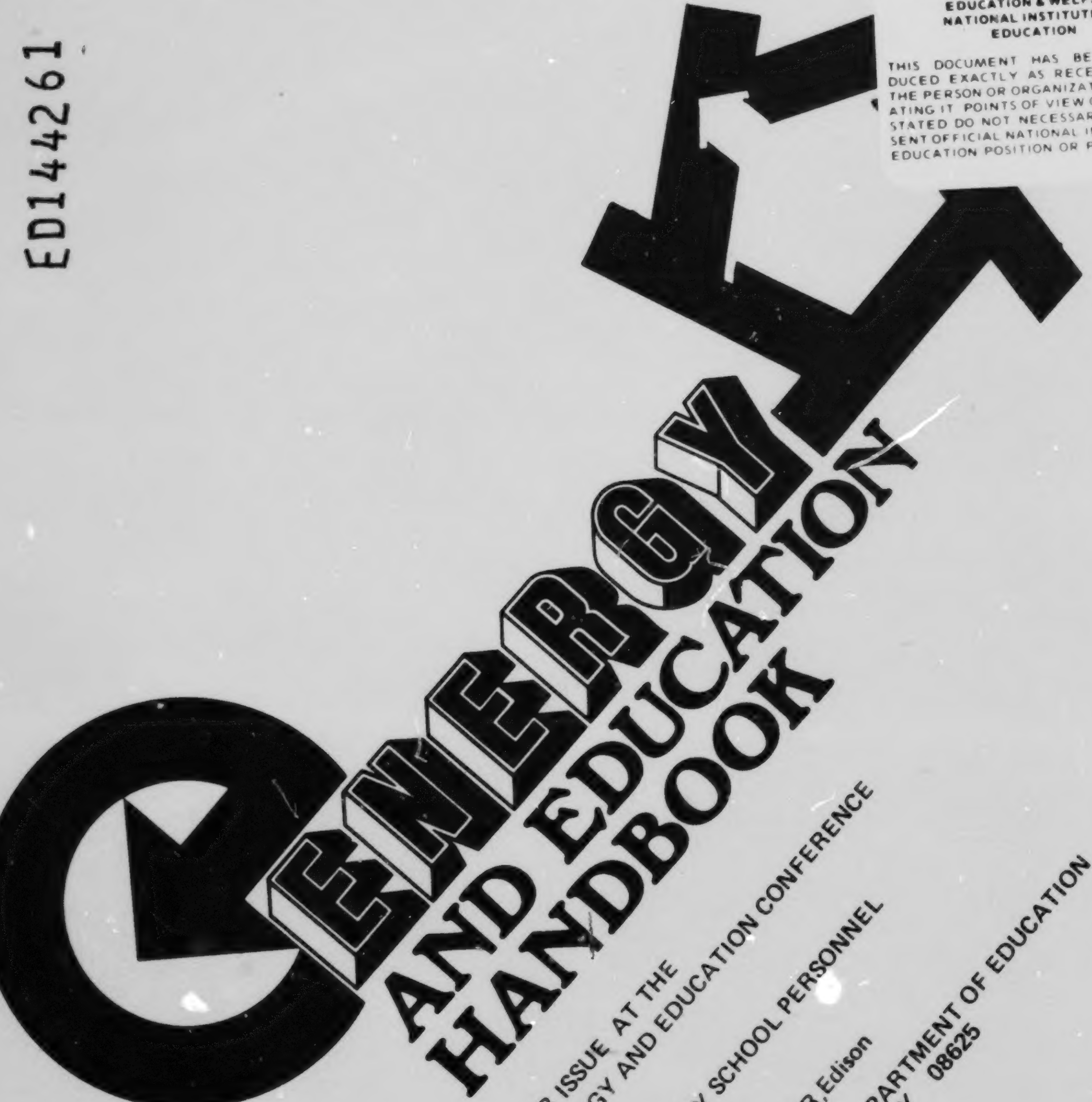

ENERGY AND EDUCATION HANDBOOK

FOR ISSUE AT THE
ENERGY AND EDUCATION CONFERENCE

for
NEW JERSEY SCHOOL PERSONNEL

held at
THE PINES MANOR, Edison
sponsored by
THE NEW JERSEY DEPARTMENT OF EDUCATION
TRENTON, NEW JERSEY 08625

OCTOBER 4, 1977

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FOCUS

The energy dilemma is one of the greatest challenges our nation ever has faced. We must once again become prudent and efficient in the use of our resources. As in past periods of crisis, the schools will play a major role in determining how successful we will be. This conference is designed to help New Jersey school people take a first, positive step in meeting the challenge.

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FOREWORD

This handbook is but a first step, albeit an important one, in what must become still another action priority for New Jersey's schools: energy education.

The problems surrounding energy are critical, pervasive and insidious. They are critical in that the earth's fossil fuel reserves are finite and are being consumed at a phenominal rate. They are pervasive in that no part of our national life -- or the life of any nation -- will go untouched. And they are insidious in that they are nearly invisible. As soon as the lines at the gasoline pumps disappeared and the closed factories reopened, the problems began to recede from the American consciousness. This, coupled with an almost mythical belief in the ability of technology to solve all problems, has combined to shut the problems from the thoughts of many of our citizens -- until the next traumatic event.

A quick look at this book shows that the emphasis in on energy conservation. This is by design. Conservation is where we, as educators and individuals, must begin. Conservation is now within our capabilities. While it is intellectually stimulating to contemplate exotic forms of energy production, and while we must not stop pursuing these, it is a fact that we will have to live with the means at hand for the foreseeable future. If there is not to be severe economic dislocation in our society including some drastic changes in the life styles of many Americans, conservation of what we have is our only alternative at present.

It is here, then, that education must begin. Let us work together so that every educator is an energy educator and that every school becomes an energy laboratory, not only for its pupils but for its community as well.

I pledge the continued efforts of the Department of Education to provide the information and technical assistance New Jersey's schools will need to do this great and vital job.

Fred G. Burke
Commissioner of Education
Trenton, New Jersey
October 4, 1977

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SECTION I

CONTEXT AND COMMITMENT

A DISCUSSION PAPER:

ENERGY EDUCATION NEEDS FOR NEW JERSEY SCHOOLS

Dr. Louis A. Iozzi, Director
Institute for Science-Technology-Social Science Education
Rutgers University

ENERGY EDUCATION NEEDS FOR NEW JERSEY SCHOOLS

Introduction

While many question the seriousness of the so-called "energy crisis" in America, others have come to recognize that Americans and indeed, the world's populations, can no longer continue to consume the earth's resources at current rates. In his attempt to impress upon society the seriousness of our energy problem, President Carter closed his historic energy message to Congress with these somber words, "...this difficult effort which I have outlined would be the moral equivalent of war." Perhaps society was convinced by these words; perhaps it was not. Nevertheless, the United States government will be taking action to conserve, and in many areas reduce fuel consumption. Surely, the demands and sacrifices that will be required of society will be real whether or not Americans believe that the energy crisis is, in fact, real.

Indeed, we are faced with a situation which will require that society react with the fervor and support of a "major war effort." Indeed, any meaningful action will require sacrifices and changes in long-established life styles. But, support and cooperation are clearly linked to the public's understanding and knowledge of the energy crisis; sacrifices and life style changes relate to the need for a new environmental ethic which, in turn, relates to values analysis and, when necessary, even values reorientation.

Traditionally, the terms "knowledge," "understanding," and "values analysis" have been associated with education. Who can deny that in the past schools have played a major role in helping to educate the public--children and adults alike--about issues that were of paramount importance to society? Who can deny that over the years schools have played a major role in bringing about social change? Who can deny that schools once again must be called upon to play a leading role in helping to meet and conquer the challenges posed by the energy crisis?

Energy education is not new to the public schools of this or any other state. Energy is discussed both formally and informally in science and environmental education courses at all levels from elementary school on up through graduate level college courses. All of us remember studying the various kinds of energy in elementary school; in general science we studied transformations of energy; in high school and college we learned about entropy, and so on...

What kind of energy education program will be necessary to help our youth meet the challenges of tomorrow? What kind of energy education program will adequately prepare our youth for the future--their future? Insofar as energy education is concerned, what should be the role of a State Education Department?

Energy Education - A New Discipline or a Subset of Environmental Education?

In attempting to respond to the energy challenge too quickly, we may find ourselves ignoring major factors related to, and in fact even responsible for, our energy problems. Too often in our efforts to react to crises with missionary-like zeal we find ourselves in the position of "not being able to see the forest because of the trees."

To talk about energy consumption alone is simply too narrow an approach to result in any meaningful and long-lasting impact on society. To talk about the importance of storm windows, insulation, car-pools, kinds of fuel, etc. without also considering the interdependent areas of natural resource management and conservation of all kinds, the types and causes of the many "pollutions," transportation, urban decay, man's interrelationship and dependence on his total environment, will result in dubious success. Simply, to promote energy education as separate and apart from environmental education is naive. Energy education always has and should be considered as a subset of environmental education as must pollution education, natural resource education, conservation education, ecological education, outdoor education and so on are subsets of environmental education. To attempt to handle energy education in a way other than in a broader environmental education context will be a grave error.

In the area of educational programs and energy education curricula, several "needs" can be readily identified for the schools of New Jersey. Each "need" also suggests several options that could to varying degrees respond to those identified "needs." Additional information in the form of advantages and disadvantages for each option have also been provided. It is anticipated that this additional information together with "recommendations" where appropriate might be useful to the New Jersey Department of Education and the Commissioner of Education in making decisions regarding future actions to be taken.

Although each need listed can be met in a variety of ways, only those options that appear to be viable in view of numerous constraints (i.e., financial, resources--human) are presented here. Similarly, the listings of advantages and disadvantages have also been limited on the basis of practicality of implementation.

Need

There is a critical need for the New Jersey Department of Education to exhibit leadership in the area of energy education. This can be accomplished by:

> Option A - Establishing a central coordinating agency to develop, implement and evaluate statewide efforts in energy education.

Advantages:

1. A single agency charged with one major area of responsibility can be more efficient and effective in carrying out its functions than a single agency charged with several areas of responsibility.
2. Concentrating all resources (human and material) in one location that is readily accessible to all school districts in the state is highly cost effective.
3. A single well-staffed and equipped agency eliminates the need for duplicate libraries, resource centers, personnel, etc. located in various places across the state.
4. A single agency can effectively administer a statewide effort in energy education.
5. A single agency can effectively coordinate proposals for funding to federal and private agencies more easily than if several separate offices were involved.
6. A single agency will eliminate the present fragmented approach to energy education.

Disadvantages:

1. It will be difficult for a necessarily limited staff to respond to a diversity of local district needs.
2. It might at times be difficult for local district personnel to get to a centrally established office or location.
3. A centrally located staff might lack an in-depth knowledge of each local school district's energy education needs.

Option B - Requiring each County Office to develop, implement and evaluate county-wide efforts in energy education.

Advantages:

1. County Offices are extremely familiar with local school district needs and can rely on established communication linkages with local districts.
2. County Offices are more accessible to local schools within the county.
3. Existing staff, resources, and LEA contacts can exert leadership in a manner which is highly cost effective.

Disadvantages:

1. Lack of expertise and funds will limit the ability of the County Offices to undertake materials development and training required to accomplish this extensive project.
2. Curriculum and program development are not major areas of responsibility for the County Offices.
3. County Offices are primarily responsible for and are presently overburdened in carrying out the provisions of T&E legislation.
4. Lack of coordination of program among County Offices will continue the current practice of fragmentation.

Option C - Requiring each regional EIC to develop, implement and evaluate regional efforts in Energy Education.

Advantages:

1. EIC's have a knowledge of local school district needs in their regions.
2. EIC's are charged primarily with providing technical assistance--including curriculum development--to local districts within their region.
3. EIC libraries exist and can be easily expanded to include energy education materials if adequate funds are provided.

Disadvantages:

1. There is a lack of expertise in the area of energy education at EIC's.
2. There is an anticipated lack of funds to employ full-time energy education consultants for each of four EIC's.
3. EIC's are presently overburdened in attempting to provide T&E related assistance to local districts.
4. The particular orientation of a particular EIC may limit its involvement in an energy education program.

Need

There is a need to treat energy education in an interdisciplinary, cohesive fashion.

Option A - Energy education can be treated as a component of environmental education.

Advantages:

1. Energy education concepts and processes are already incorporated into existing quality environmental education programs.

2. Environmental education is an established, interdisciplinary curriculum thrust with a track record, a supporting network of organizations and established entry points into LEAs in New Jersey.

3. The energy crisis is part and parcel of the environmental crisis in the state. Environmental principles regarding natural resource distribution, energy transformation and consequent environmental degradation are examples of principles common to energy and environmental education.

Disadvantages:

None.

Option B - Energy education can be dealt with by science and social science teachers as appropriate.

Advantages:

1. All disciplines have something to contribute to the resolution of our energy problems. Students must understand science and social science concepts regarding energy production, development and distribution and they must confront the difficult values questions they will face as adults in a democratic society.

2. The talents of many teachers would be tapped for the development of new curricular approaches and materials.

Disadvantages:

1. Approaches to energy education would be highly variable and fragmented from district to district.

2. The energy problem is by nature an interdisciplinary problem requiring the application of social science concepts to scientific data and conclusions. An effective energy education program must also be interdisciplinary in its conception and implementation. Material development must rely on unique teaching strategies such as simulations, role playing and dilemma debates which allow the developer to integrate appropriate scientific data into formats which simulate real world social situations.

3. Energy education must address important values questions. Today's classroom teachers have not had the opportunity to develop a values/ethical education expertise. As a consequence values analysis would most likely not be included in programs at the local level.

Need

Effective and comprehensive environmental/energy education programs and materials are necessary to develop knowledge and understanding of current and future environmental/energy issues. This can be accomplished in the following ways.

Option A - A K-12 comprehensive curriculum can be developed by a central agency to be disseminated to New Jersey public and private schools. The program and materials developed would:

1. Focus on current and future environmental/energy issues in a wholistic manner employing an interdisciplinary approach.

2. Be based on sound learning theory, suitable for the particular cognitive capabilities of students at a given age.

3. Provide opportunities for students to analyze ethical and value components in judgments and decision-making on environmental/energy issues.

4. Develop in students concepts and reasoning abilities that have generalizability over broad problem areas.

Advantages:

1. This will overcome the current lack of appropriate materials and programs for all the grade levels.

2. Environmental/energy education will become an integrated part of total environmental learning experience.

3. The efforts of an expert staff in curriculum development would be most cost-effective and avoid duplication of activities.

4. This will provide continuity in a curriculum area that currently lacks cohesion and a broadened perspective.

Disadvantages:

1. A single curriculum may not address the diversity of needs among school districts and student populations.

2. Existing curriculum in the schools may need to be radically revised to accommodate the new program.

3. Funds will have to be provided to retain and support a curriculum development staff.

Option B - A resource center to service all New Jersey schools can be established. This would include:

1. A repository containing existing programs and resource materials for teachers and administrators to examine and evaluate.

2. A consulting and information service to aid local schools in the development of a program tailored to their own specifications.

Advantages:

1. This would allow schools to freely select and adapt materials they deem appropriate.

2. No major curriculum development effort is required.

Disadvantages:

1. Existing programs are incomplete and often singular in approach.

2. There are no comprehensive K-12 programs.

3. A central resource center may not be readily accessible to all schools in the state.

4. The communication channels between the resource center and teachers may be limited.

5. Local school districts frequently lack the time and personnel to adequately conduct evaluations of resource materials.

Option C - A curriculum guide focusing on New Jersey energy issues for grades K-12 can be developed and distributed by a central agency. This guide would include:

1. Listings of possible student and teacher activities for classroom and outside classroom use.

2. Listing of references, audio-visual materials and available resources.

Advantages:

1. This will be a relatively inexpensive project requiring a minimal staff and will be easy to disseminate.

2. The activities can be adapted into the school curriculum in a number of ways.

Disadvantages:

1. Curriculum guides provide minimal assistance to the teacher and require time consuming, detailed planning on the part of the teacher to effectively execute a meaningful program.

2. Recommended resource materials are often difficult or expensive to obtain.

3. Curriculum guides often rely on materials that are not entirely appropriate, being overly general or too specialized for topics under discussion and are not adequately tested in a variety of classroom situations.

Option D - A central agency can be established to disseminate existing curriculum materials such as those developed by the National Science Teachers Association.

Advantages:

1. Minimal staffing is required to provide this service.

2. The materials are available and relatively inexpensive.

Disadvantages:

1. The materials do not provide for a complete K-12 program.

2. Materials are most often treated from a technical, scientific perspective and as a result they are used primarily by science teachers without consideration of broader social and value implications.

3. Use of the materials requires extensive planning and development on the part of the teachers to effectively adapt the program to suit the needs of their students.

4. The activities recommended may not be appropriate for a particular school because it lacks particular types of resources, e.g., equipment, physical setting, etc.

5. The curriculum materials tend to exist as a singular entity without regard to their total interrelationship in the school setting. As a result, the issues are treated in a limited fashion.

Need

There is a need to create in educators an awareness of the critical importance of the energy dilemma and to train teachers and administrators in the concept and processes of energy education.

Option A - The NJDE can rely on established teacher training institutions to provide pre-service and in-service programs in energy education.

Advantages:

1. All pre-service teachers must take a set of college courses prescribed by NJDE to receive a teaching certificate. The addition of an energy education course on the list of required courses would insure that new teachers would be exposed to techniques and principles of energy education.

2. Most school districts require members of their teaching staff to participate in in-service programs in order to progress on the salary guide. Since most teachers take one or more college courses to fulfill this requirement, the development of energy education programs at institutions of higher education would enable teachers to participate in energy related programs while meeting their obligation to continue their professional development.

Disadvantages:

1. Energy education programs do not now exist at most colleges. A strategy for developing and supporting such programs would have to be devised.

2. The college program is already crowded with courses required for graduation by NJDE, the college administration or both.

Option B - The NJDE can design, finance and implement an inservice energy education program to enable teachers to incorporate interdisciplinary strategies and materials in existing courses of study.

Advantages:

1. Practicing teachers would be provided with developed and tested materials to be implemented in the classroom.

2. A minimal training staff would be required to conduct one or two session training programs. The program would therefore be cost effective and would reach large numbers of teachers.

3. Program content and format would be uniform from district to district. Interdisciplinary approaches would be introduced to many districts where they are not now being used.

Disadvantages:

1. Pre-service teachers would not be exposed to energy education strategies and concepts through this program.
2. Local school districts would have limited input into the format and content of the training program.

Need

There is a need to instill an energy ethic in students as a component of citizenship education.

Option A - The developed program can provide students and teachers with the opportunity to examine the value implications of their actions and to clarify their values about energy issues.

Advantages:

1. A body of research and expertise exists which indicates that classroom strategies can be devised to lead students to an understanding of their values.
2. The schools of New Jersey have beeh charged with the responsibility of developing and implementing a citizenship education program. Since citizen partcipation in energy decisions will become increasingly important in the future, provision should be made in the school curriculum to prepare students to make informed personal and public decisions.
3. Values clarification techniques can be used in a variety of classroom situations and subject areas.

Disadvantages:

Values clarification may not provide adequate opportunities for students to test their value constructs against opposing views and to experience ethical or moral growth.

Option B - The developed program can foster ethical/moral development on energy issues by using dilemma debates to encourage students to challenge and defend their own value systems and those of their peers.

Advantages:

1. The research of Lawrence Kohlberg at Harvard University indicates that moral development is a sequential process occurring in all individuals and that such development can be fostered by engaging students in dilemmas/debates.

2. The dilemma debate process is readily adaptable to a variety of issues and positions.

Disadvantages:

None.

ENERGY AND SOCIETY

Dr. Robert Weber
Division of Research, Planning and Evaluation
New Jersey Department of Education

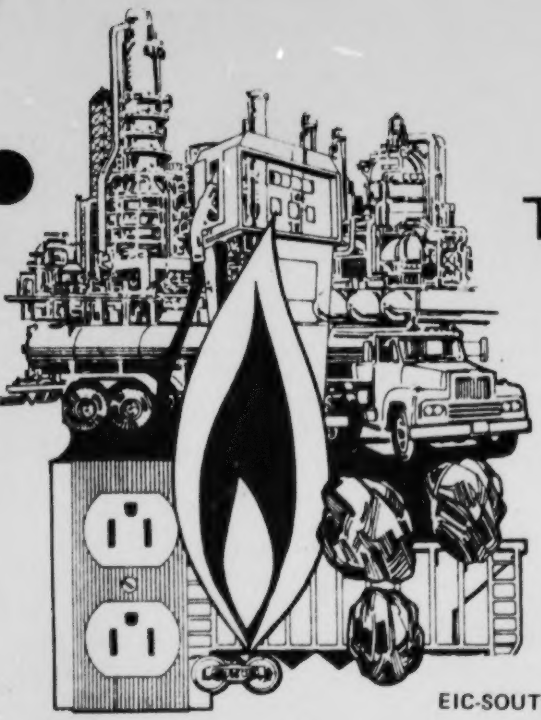
While it is possible to deal with the topic of energy as a discrete entity, energy cannot easily be removed from its context: it is a subset of ecology. Moreover, the first law of ecology, as stated by Barry Commoner and others, is that everything is related to everything else. Thus, kinds and amounts of energy use relates to values, ethics, attitudes, and lifestyles; relate to patterns of production, distribution, and consumption; relate to the generation/accumulation of disamenities and their costs; relate to quality of life and trade-offs; relate to waste disposal and its costs; relate to world trade and demographics; and relate to politics and health.

Given this interdependency and inter-relatedness, it would not seem fair, prudent or pedagogically sound to expect students to deal successfully with a complex subject devoid of its context. Rather than curricular fragmentation, students require systems thinking. In fact it is only through systems thinking that students will be able to do anything meaningful in restoring ecological balance, in cleaning up the environment, and in formulating workable plicies and modes of operation in the new and radically different years that lie ahead.

We are placing a terrible burden on the youth of today and the generations which will, with luck, come after them. Humankind in the developed countries "went exponential" as the Industrial Revolution progressed. Many critical curves shot up steeply with astonishing rapidity and in the process we defiled the environment, wasted resources, and violated the laws of nature. In effect, we mortgaged the future of today's kids and tomorrow's kids. The epitaph for the generations since the Industrial Revolution might well read: "They took more than their share and used it neither wisely nor well."

And now nature is applying the brakes to these exponential curves and the more rational among us admit to our folly, reject the forces we have set in motion, and offer young people a belated Epimethian view: 20-20 hindsight in a spoiled world. Our obligation is now to tell them: "Live as though there will be a surfeit of tomorrows; do more with less; believe that small is beautiful; use only appropriate technology; develop a reverence for the earth; tax yourselves doubly for the common good; control your numbers; and bring about more perfect justice."

But, educationally, our burden is great and most serious. The youth of today and tomorrow are relying on us to provide them with the tools they need if they are to be successful at living in the years ahead. Chief among the measures we need to bring to bear in today's schools are the inculcation of systems thinking, wholistic thinking, and interdisciplinary thinking. Many of today's academic concerns pale to trivialities compared to the formidable tasks that lie ahead for the new passengers on Spaceship Earth. "Education For Survival" may be the most appropriate appellation.



ENERGY:
THE DIMENSIONS OF CRISIS

Far more dangerous then dried up oil wells and depleting natural gas reserves is the current state of public confusion over world energy problems.

Because of its paralyzing effect on our collective will to act, this confusion poses the most immediate energy challenge.

BY RON ZUCCA
EIC-SOUTH, N.J. DEPARTMENT OF EDUCATION

Last year, as America shivered through its two-hundredth Winter, the only thing more chilling than the record low temperatures was the record high shortage of fuel. Evening newscasts abounded with e sights and sounds of employees out of work, hildren out of school, and department stores out of thermal underwear.

It was the second time in four years that something called the energy crisis moved out from between the covers of 'Future Shock' and onto the front pages of the daily newspapers.

What we experienced during the Mid-east oil embargo of 1973, and last Winter's natural gas crunch was more than temporary long lines at the pump and 65° thermostat settings. In both instances we glimpsed the chilling images of an existence without an abundant supply of cheap fuel. So detrimental to our societal goals, so opposite our expectations for the quality of life were those images, that they forced a newly inaugurated president to declare the energy crisis to be the moral equivalent to war.

Most independent energy observers believe that, as a declaration of severity, the President's analogy was either right on target or an understatement--none, however, view the analogy as being too strong.

Why then is the public not heeding the President's ll to arms? Why is the weaponry needed to confront the energy crisis not being rushed into place? Why has the Congress not declared that a state of all-out war exists? In short, why is there no comprehensive federal/state/local policy in place that has the sanction and committment of public support.

Clearly, a credibility gap exists between those who are trying to mobilize the people against the crisis and the people themselves. Misleading, confusing, sometimes questionable information from and about government, business and special interests groups compound the problem.

Last spring, George Gallup went through his latest survey results dealing with energy issues. He found that if Americans were tested on their knowledge of the energy crisis, the majority would flunk.

At a recent National Energy Conference held in Washington, D.C., Dr. Charles Cicchetti offered this compelling appraisal of the world energy dilemma, 'Whether we want to address it or not, we must recognize that there are real long term energy resource limits. Not long term in terms of hundreds of years, but in a matter of a decade or two at the most.'

Dr. Cicchetti is the Chairman of the Wisconsin State Public Service Commission, member of the Midwest Governor's Conference's Energy Task Force, and holds positions on several advisory committees for the Federal Power Commission and the Federal Energy Administration.

The importance of Dr. Cicchetti's credentials is that they've given him a perspective of the crisis that the majority of citizens can't seem to gain. His position in life places him on the knowledge side of the energy information gap. This information gap that exists between the public and the facts puts citizens in the position of having to make critical energy related decisions in a state of virtual ignorance.

Is it imperative to trade in that sleek, roomy, guzzler for a four cylinder motor midget? Is a chilly 65° thermostat setting in mid-winter really in the national interest?

Should we nix nuclear, support solar, condemn coal, or think thermal?

Dr. Cicchetti feels that critical decisions regarding conservation and alternative fuel sources are being deferred because the dimensions of the energy crisis are either not known or not understood.

Along with the problem of general mistrust of the oil cartels and governmental decision making, Dr. Cicchetti blames what he calls the 'Apollo Syndrome' for the public's lack of understanding. Simply stated, this mind set holds that a technology that can put a man on the moon, can turn sea water into premium gasoline. What science can do, it can undo.

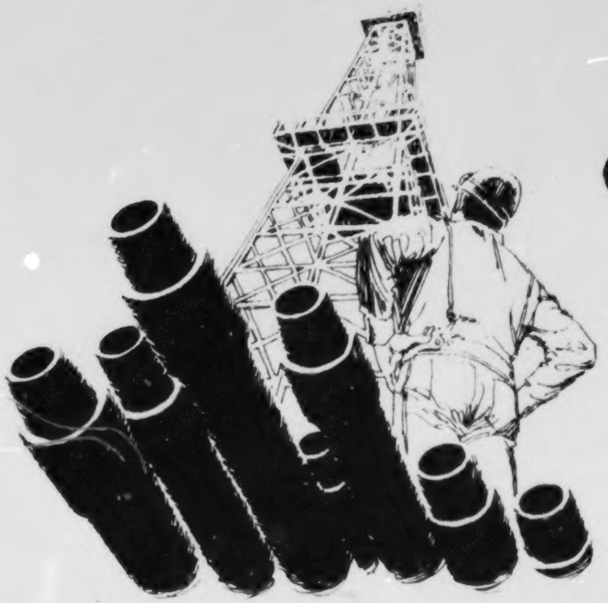
While Dr. Cicchetti and most other energy watchers believe that technology can eventually answer most tough energy concerns, they point out that the time needed for scientific breakthroughs to emerge and be installed is far greater than the public imagines.

The fact is that inventions will be made; they are being made. Many of the world's greatest minds are working on solutions to energy challenges. Some potential solutions include power from the tides, wave motion, the winds, derivations of plants and fusion. But new discoveries cannot be tested, scaled-up, proved environmentally safe and constructed on a scale big enough to make a dent in the problem over the next couple of decades.

A crisis in energy does exist. If we perceive it as simply an oil cartel plot to jack up profits, our Winters will become increasingly colder. If we interpret it as a minor temporary problem to be tamed by technology, our natural environment will become increasingly wasted. If we view it as only a political football being tossed about by politicians trying to score votes, our economy will be shattered, and if we think it's a problem that doesn't require the personal involvement of every citizen, we may cease to exist.

TOWARDS UNDERSTANDING

A problem whose dimensions are not understood is a problem with little hope of being solved. For the most part the salient characteristic of the energy crisis is confusion. This confusion is much more dangerous than things like depleting oil reserves and dried up natural gas wells, because of the paralyzing effect it has on our collective will to act.



The first step then in solving our energy problems is to cut through the confusion with a reliable assessment of future energy needs and the fuel options we have for meeting them. Within the assessment of fuel options, we need unbiased appraisals of the advantages and disadvantages of each alternative energy source. Once citizens and the institutions which serve them understand consumption requirements, once they realize the environmental, social and economic consequences of the fuei options available, then, and only then, can the hard decisions be made.

The nation has before it then, three questions which must find answers in the next several years. They are:

1. **How much energy do we need?**
2. **What fuels comprise the list of options available?**
3. **What is the usage mix of these options that will fill consumption requirements without having a disastrous effect on our economy, environment and social welfare?**

As might be expected, absolute answers to these questions do not presently exist--at least not to the point that comprehensive nationally agreed upon plans have moved off the drawing boards and into operation. What does exist is an ever increasing bank of information.

Granted, some of this information has been filtered through special interest screens, other information has been confused by differences in scientific interpretation--but all this notwithstanding enough hard data exists to help in shaping answers to the three crucial energy questions.

Examples of this data and methods for analyzing them follow.

HOW MUCH ENERGY DO WE NEED?

Richard E. Balzhiser is the director of the Fossil Fuel and Advanced Systems Division of the Electric Power Research Institute (EPRI). His knowledge of and experience with energy are well known and widely respected.

Balzhiser has tackled the question of how much energy is needed by averaging the consumption projections of 14 national studies.

The projections are for the year 2000 and were made by such agencies as the Environmental Protection Agency, U.S. Atomic Energy Commission, Council on Environmental Quality and the Federal Energy Administration, just to name a few.

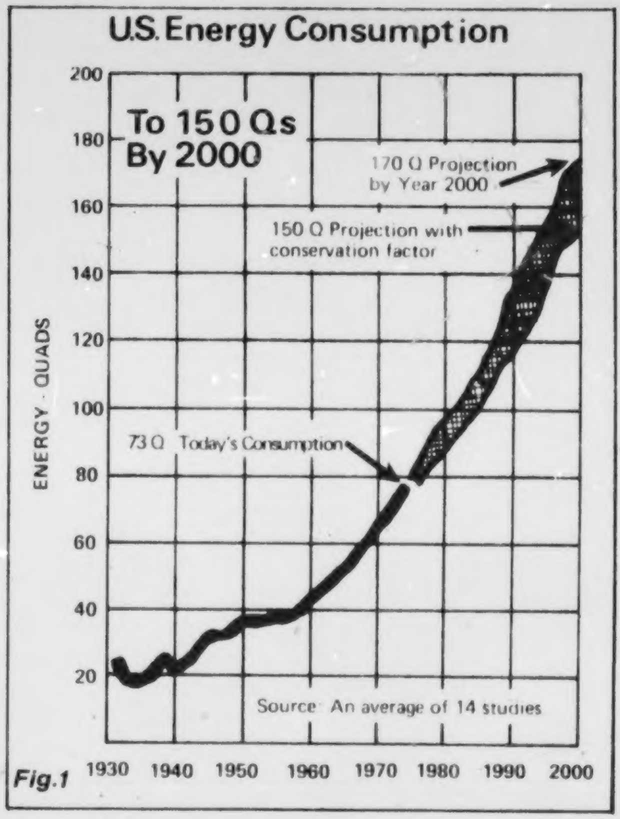
To understand Balzhiser's findings, one piece of energy terminology must be defined; the Quad (Q). A quad is to energy what the yard is to a football field: a convenient unit of measure. For the technically minded, a quad is a quadrillion BTU's. If that definition doesn't produce an immediate Aha, try this one. A quad is seven and a half billion gallons of gasoline--enough to run 10 million automobiles for a year. Or, to put it another way, a quad is about the total energy used by a United States city of 1 million people every three years.

Now back to Balzhiser's findings (Fig. 1), Balzhiser found that U.S. energy consumption today is about 73Q. By the year 2000, that figure will more than double. An analysis of growth rates based on a projection of the historical relationships among energy consumption, employment, and the GNP reveals that this nation will consume around 170Q by the end of the century. The presumption, of course, is that growth is necessary.

Balzhiser then subtracts from the 170Q projection a 20Q estimate for energy savings due to conservation efforts. The 20Q estimate is based for the most part on what is known about technology's ability to improve the fuel efficiency of transportation vehicles, industrial machinery, and appliances.

So using Balzhiser's averages of 14 national forecasts we see that to maintain growth rates, by the year 2000 we'll need to produce 150Q of energy 170Q actual, minus 20Q for conservation = 150Q. The 150Q figure gives us a handle on our first question: How much energy do we need?

Balzhiser's approach is not the only one. It does embrace the findings of many independent agencies as well as attempt to factor in a savings due to conservation efforts. In that it does these things, it represents a hook to hang the problem on.



Source: An average of 14 studies

Fig.1

WHAT ARE OUR FUEL OPTIONS

The 73Q of energy the U.S. consumes today is derived from a number of different fuel sources. The breakdown (Fig. 2) is as follows. Domestic oil contributes approximately 15Q, with an additional 15Q supplied by oil imports. Natural gas kicks in 23Q, coal 14Q, nuclear 2.5Q, and hydroelectric 3Q. Other sources of power, such as solar, wind and geothermal, account for the remaining 3.5Q.

The crux of the energy crisis, at least for the remainder of the century, lies in how much energy we can continue to squeeze from the old reliables like oil and natural gas and how much power we can learn to safely and effectively generate from new arrivals like solar and nuclear energy.

Balzhiser and others have made some projections that can help to shape expectations of the future contributions of known fuels. A review of their scenarios for domestic oil and natural gas will further clarify the dimensions of the energy crisis.

By the year 2000, domestic oil production will actually increase from the 15Q it supplys today to about 30Q. Favorable economic incentives will offset the financial risks of finding and retrieving hard to reach oil. In addition, it will become profitable to recover oil from old and existing wells that up to now has been ignored because of the expense of recovery at great depths.

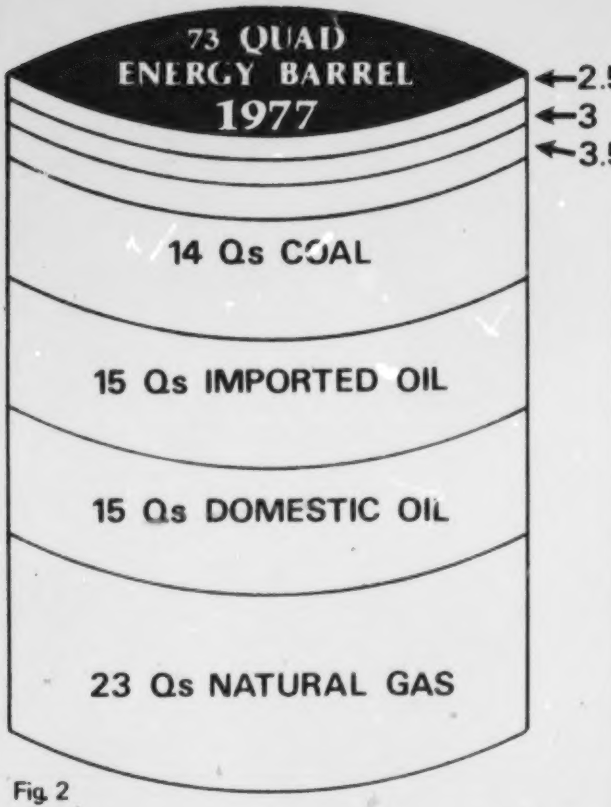

73 QUAD
ENERGY BARREL
1977
2.5 Qs NUCLEAR
3 Qs HYDROELECTRIC
3.5 SOLAR-WIND-GEOTHERMAL
14 Qs COAL
15 Qs IMPORTED OIL
15 Qs DOMESTIC OIL
23 Qs NATURAL GAS

Fig. 2

The forecast for natural gas is not nearly as comforting. Depleting reserves will drive its contribution down from 23Q to 15Q by 2000.

Domestic oil and natural gas, by the year 2000 will provide approximately 45Q of the projected 150Q needed by the U.S. This leaves 105Q to be provided in some combination by other sources (Fig. 3).

WHERE DO WE GET 105Q

The problem is not whether or not we can produce 105Q worth of energy, the problem lies more correctly in how we can produce it. Most of that giant 105Q could come from our coal reserves alone. But if it does, the effect on our environment would be disastrous. Solar, on the other hand, while environmentally safe, poses developmental challenges that preclude its turning into a major contributor by 2000.

Each alternative fuel source carries with it advantages and disadvantages (Fig. 4). Determing the proper future fuel mix is our most immediate energy challenge. Coming up with the recipe that supplys enough power to meet projected needs without sacrificing our environment or our economy should be the foundation of any energy policy.

Sound conservation practices must be factored into any future energy formula.

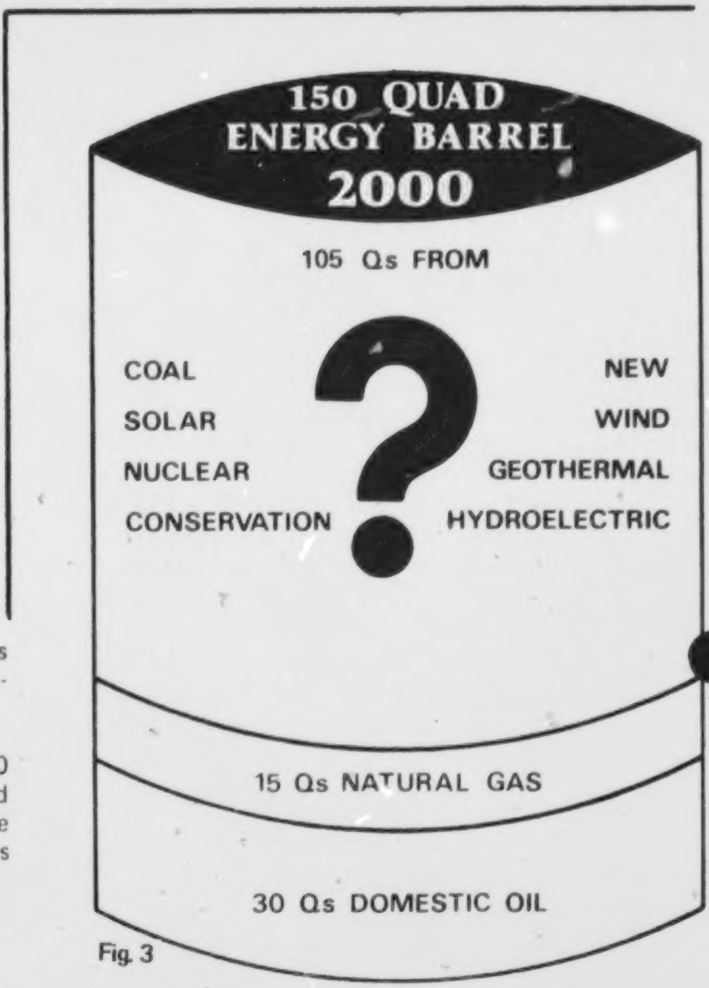

150 QUAD
ENERGY BARREL
2000
105 Qs FROM
COAL
SOLAR
NUCLEAR
CONSERVATION
?
NEW
WIND
GEOTHERMAL
HYDROELECTRIC
15 Qs NATURAL GAS
30 Qs DOMESTIC OIL

Fig. 3

The elimination of wasteful energy usages can shave that mammoth 150Q down to a smaller figure, thereby making what we know will be hard trade-offs regarding fuel use a little easier.

Figure 3 represents the questions that need immediate answers. Within these questions rests the energy role of this nation's institutions. Within the institutions rests the public's hope of making a smooth transition through the energy crisis.

On January 1st, 2000, we will need to have available 105Q of energy in addition to that supplied by domestic oil and natural gas. Even if we're only five Q off, we will be in serious trouble. The 1973 Arab oil embargo that threw thousands out of work, spawned a national depression, and created unpricidented lines at gas pumps reduced our fuel supply by only about one Q.

FIGURE 4. ADVANTAGES AND DISADVANTAGES OF SOME MAJOR FUEL SOURCES

ADVANTAGES	DISADVANTAGES
Domestic Oil Compatable with most current technology Off shore deposits and shale deposits hold potential for supplying vast reserves. Poses modest environmental risks - both in recovery and use. Relatively easy to transport.	Production has been on the decline for the past seven years. Most easy-to-retrieve oil has been recovered. Oil from offshore reserves and shale deposits will be costly and difficult to retrieve until breakthroughs in technology occur. Experts agree that as a long term contributor domestic oil holds little potential.
Imported Oil Same as for Domestic Oil	Same as for Domestic Oil. U.S. supply is heavily dependent on geopolitical events outside of the nation's direct control. Use has an adverse effect on U.S. ballance of trade and therefore on the nation's economy as a whole. The OPEC Nations will in all probability begin to place ceilings on production to extend the life of their reserves. This will put severe limits on future U.S. supplies.
Solar Abundant now and will be for the life of the planet. Equally distributed world wide. No transportation problems. Environmentally hazzard free. Versatile in use - can be converted into heat and/or electric power.	Technology.....knowledge and equipment are the major shortcomings . The technology needed to make solar a viable contributor in the short run does not presently exist. Breakthroughs will undoubtedly occur - solar is to promising to dismiss - but the developmental and installation time factors preclude it coming to the rescue during this century.

FIGURE 4 CONTINUED

ADVANTAGES	DISADVANTAGES
Coal Abundant......reserves within U.S. boundries are vast. The lowest estimates suggest we have 200 years the highest predictions say 1000 years. Versatile.....coal can be turned into gas or oil. Experience.....we have used coal as a fuel for many years. Our familiarity with it will be useful in solving its problems.	Retrieving it.....digging coal from underground mines is dangerous – we lose several hundred persons per year and this figure will grow as workers are forced deeper and deeper to locate coal veins. Strip or surface mining destroys the environment and land reclamation techniques are far from proven. Transporting it.....enormous transportation problems must be solved if coal usage is to be expanded. Railroads bear the brunt of the burden and most U.S. rail lines are deteriorating. Burning it . . . Expels large quantity of pollutants into environment. There is a great deal of controversy over whether or not present stack scrubbers are adequate.
Nuclear Abundant.....the light water reactors which utilize uranium hold short term promise while the breeder-reactors, which use plutonium - and actually produce more fuel than they consume - hold real long term benefits. Environmental.....retrieval of fuels does little harm to the land and there are no harmful emissions from the conversion process. Virtually no problems in transportation of fuels.	Uranium faces the same long term depletion problems as oil and natural gas. The light water reactor plants pose the risk of accidents occuring which would emit radioactive material into the environment. Disposal of the radioactively charged waste from nuclear conversion currently poses environmental problems. Fosters the potential for terrorists to secure nuclear materials from which weapons can be fashioned. Great deal of public controversy regarding the use of nuclear power.

INTRODUCTION TO
THE NEW JERSEY ENERGY CONSERVATION PLAN:
A NECESSARY COMMITMENT

Submitted to the Federal Energy Administration by the
New Jersey State Energy Office
March 28, 1977

During the oil embargo and price increases of late 1973 and early 1974, the United States took immediate steps to curtail energy demand. During the 6-month embargo, the executive and legislative branches of the government favored energy policy initiations that focused on extended price and allocation controls in the short term, and the longer term development of additional domestic energy supplies. However, after 6 months, the embargo was lifted and, by the end of 1975, energy demand began to rise again. Correspondingly, oil imports began to rise, in absolute terms as well as in percent of total petroleum supply, thus making the nation more dependent than ever on foreign oil imports for a substantial portion of its energy requirements. At the same time, domestic production of natural gas continued to decline, which has, as seen during the recent natural gas supply crisis, resulted in serious economic problems in many parts of the nation. For example, a December 1976 report, prepared by Princeton University's Center for Environmental Studies, stated:

> "No state in the nation, in fact, has a gas shortage greater than New Jersey in terms of both volume and percentage of curtailments. Some have lost a greater volume of gas; others have faced larger percentage curtailments - but none ranks higher in both categories... The state's access to gas seems likely to get worse rather than better for at least the remainder of the 1970s. Industrial customers already face serious deletorious impacts, and even residential consumers (the highest priority under FPC regulations) may be threatened in the event of a cold winter..."*

The growing natural gas supply shortage has revitalized national interest in and reemphasized the immediate need for energy conservation and efficiency. In December 1975, several significant conservation measures were passed by Congress. For example, the Energy Policy and Conservation Act established voluntary conservation targets for the 10 most energy-intensive industries. In addition, appliance labeling and efficiency improvement programs were enacted. And, to involve state governments in federal energy conservation efforts, a grant program was established under which the Federal Energy Administration (FEA) would set guidelines and procedures for states to receive financial and technical assistance to develop and implement statewide energy conservation plans.

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*J.L. Cecil and D. Morell, New Jersey Natural Gas Shortage: A Policy Analysis (Princeton, N.J.: Princeton University Center for Environmental Studies, December 1976), p. 2.

All 50 states have announced their intentions to participate in the grant program. To qualify for funds, a state must present to FEA a credible energy conservation plan that will save 5 percent of the state's estimated 1980 energy consumption by 1980.* At a minimum, the plan must contain six specific conservation measures:

1. Right turn on read.
2. Thermal efficiency standards for new and renovated buildings.
3. Lighting efficiency standards for public buildings.
4. Promotion of car pools and van pools.
5. Promotion of public transit.
6. Energy-efficient state procurement practices.

As an early step in a longer range, more comprehensive energy conservation program for the state of New Jersey, the New Jersey State Energy Office (SEO) has prepared this state Energy Conservation Plan for submission to FEA to obtain the financial and technical assistance available under the grant program. In the course of preparing the plan, SEO met with representatives of most state agencies responsible for administering and implementing the selected measures. In addition, meetings were held with industry representatives and public interest groups to gain their comments on and inputs to the contents of the document.

The conservation measures included in the plan were selected on the basis of their ability to save significant amounts of energy by 1980. Specifically, the plan includes the six measures required by FEA, which will save somewhat less than 2 percent of the state's energy requirements in 1980. In addition, to realize the remaining 3-percent savings, a number of other, mandatory conservation measures were chosen. Given the 1980 deadline, these selections were confined to measures with: (1) large, short-term energy savings potential and relatively low capital investment requirements; (2) applicability primarily to existing stocks of buildings and vehicles; and (3) early, relatively easy implementation possibilities.

Overall, the 22 conservation measures included in the New Jersey Energy Conservation Plan will save the state approximately 110 trillion Btu annually (over 50,000 barrels of oil per day), or 6 percent of the state's projected energy use in 1980. At an assumed cost per barrel of fuel oil (equivalent) of $14.50, the annual energy savings equals $278 million to New Jersey users. The resulting $3 billion in savings through 1989 more than counterbalances the cost to the public and private sectors of about $735 million through 1989.

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*Each state is allowed to include in its plan energy-saving measures that have been implemented since December 22, 1975, the date the enabling federal legislation was signed into law.

SECTION II

CURRICULUM MODELS

A TEACHER'S INTRODUCTION TO
ENERGY
and
ENERGY CONSERVATION

This material was developed by the Division of Educational Redesign and Renewal, Ohio Department of Education. The New Jersey Department of Education gratefully acknowledges the permission of the Ohio Department of Education to reproduce it.

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INTRODUCTION

At no other time in the history of our country has there been a greater need for a national commitment to conserving existing energy sources and seeking new ones. A united effort by all Americans is necessary to fulfill this commitment. There is no better place or time to begin than in today's schools, with students who will be tomorrow's adults. It is their lives which will be affected by the energy practices and policies of the present.

The teacher's responsibility is a critical one in teaching about the sources and uses of energy, the multi-faceted problem, and the energy conservation ethic. Attitudes, along with technology, are important in working toward solutions.

The Division of Educational Redesign and Renewal coordinates the Ohio Department of Education's inservice center. One of the division's major responsibilities is the development and dissemination of INDIVIDUALIZED INSERVICE PACKETS, practical resources for independent study or for the use of teacher-leaders working with groups of colleagues. A *Teacher's Introduction to Energy and Energy Conservation* is another of these stand-free inservice resources.

This material is intended to give the teacher background information and general suggestions for teaching units and correlated learning activities. Sections are directed to: A Problem Shared by All, Causes, What Is Energy?, Energy Sources, Searching for Solutions, Conservation: An Ethic for Everyone, a glossary, and an extensive bibliography. The background information has been written for all teachers from the kindergarten through the secondary school. Four teaching units provide for the differentiation of instruction: kindergarten-primary, upper elementary, middle school, and high school level.

In addition, a slide pocket is provided for examples of slides related to energy education. Teachers and students are encouraged to build a slide collection by taking pictures which show energy sources, uses, conservation practices and industries in the nearby community.

The major goal of this inservice publication is to give the teacher orientation to energy education and the encouragement to do research and teaching beyond the initial, condensed content. Another goal is that the materials will stimulate school districts to build energy education into the curriculum.

WHAT IS YOUR E.Q.? (Energy Quotient)

1. Why are our major fuels called *fossil* fuels?
2. What are the three principal fossil fuels?
3. Name three nonfossil sources of energy.
4. Of the nonrenewable fuels, which is most abundant?
5. Give examples of how the study of energy can be related to science, mathematics, social studies, literature, art, music.
6. What are the basic causes of the energy problem?
7. What are positive features of the energy shortage?
8. What two categories combined take over half of the average American family's energy budget?
9. What is the primary use of transportation energy in our country?
10. Why is electricity called *secondary energy*?
11. In what two ways does electrical power waste energy?
12. How were substantial quantities of natural gas reserves wasted?
13. What options do we have to meet energy demand?
14. How is *energy* defined in physics?
15. What are the two states of energy?
16. What two kinds of energy transformations take place in the sun which man has learned how to duplicate?
17. The three types of energy conversion processes are mechanical (physical), chemical, and nuclear (atomic).
    - (a) In which of these processes is waste heat generated?
    - (b) Which is the primary process responsible for all the energy we have?
    - (c) Which process takes place in a storage battery?
18. What unit is used commonly to measure potential or kinetic energy?
19. How is efficiency of the energy process defined?
20. What are the advantages and disadvantages of electricity?

21. When a substance is heated, it increases the movement of atoms, therefore, heat is really what kind of energy?

22. Uranium, green plants, coal, natural gas, sunlight, fuel oil, oil shale, and hydropower are sources of energy.

    (a) Which of these sources are renewable or continuous?

    (b) Which of these sources are nonrenewable or exhaustible?

23. What generalizations can be made about fossil fuels?

24. Which of the fossil fuels is most abundant in Ohio?

25. What invention gave the impetus to supplant wood with coal?

26. What are some advantages in using oil or gas over coal?

27. Which fossil fuel is the principal one not being completely utilized in the United States?

28. What energy conversion process may ultimately create the biggest new market for coal?

29. What are possible sources of energy for the future?

30. What change took place in November, 1970, that gave us cause to worry about our future oil supply?

31. What is the goal of Project Independence?

32. Name three technology advancements being made in the energy field.

33. What are three advantages of recycling?

34. What are problems in total recycling of throwaway materials?

35. What ways does the concern for natural environment figure in the energy problem?

36. What factors will encourage the development of new energy resources?

37. What is the energy conservation ethic?

38. How can the energy conservation ethic be practiced in schools?

39. What are some conservation measures which may be practiced in the home and community?

40. How can local, state and national government assist in the conservation of energy?

A PROBLEM SHARED BY ALL

As we are gaining a realistic view of the energy problem, we have become aware of the finite nature of fossil fuels. Our students also need a comprehensive appraisal before they can devise ideas for solutions.

QUESTIONS TO GUIDE YOUR READING

At present consumption rates, when do the optimists say we will run out of domestic oil resources in the United States?

When do pessimists say we will run out?

How long will our domestic coal last?

In what ways can the study of energy be related to

science

mathematics

social studies

literature

art

music?

What is the primary cause of the energy problem?

A PROBLEM SHARED BY ALL

We in America are a problem-solving society. We live in the spirit of "Can do!" and, while we no longer believe that every problem has a simple solution, we believe that man, if he looks hard enough and works hard enough, can do much about improving his own living conditions. In this sense, we, like our pioneer forefathers, are pragmatists. Our approaches to recent problems continue to evidence this.

As an example, putting a man on the moon was the result of a clearly defined approach to a specific problem, with implications which reached into classrooms, where the challenge was to improve science education. More recently, our efforts to clean up the environment have had their roots in largely successful ecological programs in the schools. There is no reason to assume that the readjustments required by a new understanding of the value and scarcity of energy sources will not also have their roots in education.

Yet, the "energy crisis" is a most perplexing problem. Daily, the headlines add to the confusion. We must reduce oil imports and cut down on gasoline consumption; yet we depend on the automobile for shopping and getting to work, and in Ohio many of us owe our jobs to the automobile industry. We turn down the thermostats and sometimes shiver in chilly classrooms to conserve natural gas; yet we are told that America has enough coal for many hundreds of years if only someone can find ways of using it properly.

But we have, at least, made some progress toward recognizing the problem. In the 1960's, when the warnings became clear, many of us simply didn't believe them. Then, when we began to feel the pinch, some of us blamed the industrial and political sectors of our society. It seemed inconceivable that America suddenly could go from an abundance to a shortage of fuel. But no longer! We at last are beginning to realize what the economists have been saying since before today's teachers were in school: "As the cheapest energy sources are becoming exhausted, the *real* costs are going up."

While this is a problem shared by all of us, it is not a situation which is all bad. As we recognize, for example, the extent of our dependence upon foreign suppliers, we realize that the United States must move toward self-sufficiency in energy supply. The longer we wait in working towards solutions, the fewer options we will have. The evidence is clear that the era of cheap fuel is ended. It is, however, not a matter alone of fuel becoming more expensive. The greater problem is diminishing availability based on past and present rates of consumption. At issue, therefore, is the question of our nation's whole value system. As readily available domestic supplies of coal, natural gas and petroleum dwindle, earlier values which have led to unrestricted consumption must yield to reality.

Historically, energy sources have been supplanted by newer, more efficient sources. Early man found he could augment his own muscle power with the muscle of animals for a greater power supply. As civilization advanced, wood became a chief source of power. During the Industrial Revolution, coal supplemented and then replaced wood as the fuel to power rapidly growing and expanding industry.

Now, fuel supplies are waning. Our search for alternatives suggests that we could be on the brink of another technological revolution in energy—the discovery of new sources and conversion processes.

The table below strikingly indicates that a number of sources of energy may be depleted within the life spans of students now in school.

But even this does not say enough. As supplies of oil and gas level off and decrease, we obviously will no longer be able to get nearly 80 percent of our power from them. Coal reserves are great, but there may have to be trade-offs between coal availability and environmental factors. Strip mining is the only cost-effective way to reach many of our coal reserves. Nor is it economically feasible to remove the sulfur in most of our bituminous coal, using presently available technology. Nuclear fuel reserves are far greater than the projected 100-year supply if technological development of advanced nuclear power plants (breeder reactors) is continued. Yet, nuclear power development has been painfully slow and is attended with complex environmental and health concerns. Today nuclear power accounts for only about two percent of our total energy budget. Shale oil reserves in Wyoming, Colorado, and Utah are great, but here again there are monumental pollution problems. "Cooking" oil shale to release the oil causes the rock to swell and produces alkali compounds which pollute soil and water.

The situation is not hopeless. New sources of oil are being discovered. New ways are being found to convert coal to gas. New research is pointing to more efficient uses of atomic energy. And new ways are being found to use old energy sources: the energy of the earth, the sun, the winds and the tides.

But all of this will take time, and it will demand the use of our best brain power. Today's children need to learn to cope with the situation as it is being presented to them, and they must be prepared so they may do something about it. Providing energy-focused instruction will be an ongoing activity, for it will require us to stay aware of swiftly changing use patterns and priorities. The problem is more than a matter of adequate supply; we must decrease our rate of consumption while working toward solutions.

Understandings about the sources and uses of energy and a commitment to energy conservation require teaching-learning emphasis. And it is not enough simply to come up with lists of "helpful hints" that students can take home to their parents. Certainly, conservation of energy should start in the home. However, if conservation is to be meaningful, there must be an understanding of what energy is, where it comes from, who uses it, why and how it is used.

The role of energy has bearing upon various school subjects. The correlations with science and mathematics are readily noted. However, there are others. The sun, the ultimate energy source, has had a dominant influence in music and art. History chronicles the advancement of societies in relationship with energy use.

Our Fuel Predicament

U.S. Energy Resources	Potential Reserves	Known Reserves	Years Left
Oil	100 billion barrels	35 billion barrels	10-30
Natural Gas	1000 trillion cu.ft.	250 trillion cu.ft.	10-30
Coal	3.25 trillion tons	1.5 trillion tons	500-1000
Nuclear Fuel (uranium)	1.7 million tons	.7 million tons	100 (~1000 with breeder reactors)
Shale Oil	Unknown	200 billion barrels	Unknown

Note: Figures are *estimates* derived from several sources. Estimates of energy resources vary widely, often depending to some extent on the interests of the estimators.

Literature tells of the lives of people involved in the development of energy. Examples are novels such as Richard Llewellyn's *How Green Was My Valley* and A. J. Cronin's *The Stars Look Down*. The Molly Maguires (19th century militant Pennsylvania miners) are the subjects of nonfiction works.

Although energy use is so much a part of the daily lives of Americans, studies indicate a general lack of awareness about sources of energy and how energy is used to generate power. The sources of energy used today are simply taken for granted.

It is hoped that students will reverse this carefree "flip of the switch" psychology by becoming fully and well informed about energy, uses, consumption and related problems. Future responsibility will be upon their shoulders. It is not too early, even at the kindergarten level, to begin thinking about new and innovative ways of saving energy and unlocking new resources.

For these exercises, our text can be the real world as it exists and changes. And our school setting itself can become a model energy conservation center. We can maintain lower temperatures, use lights and paper carefully, and then in a mathematics class we can calculate the effects to see what they really mean. Or in a driver education class we can study the energy saving (as well as safety) aspects of good driving habits. In social studies we can study the energy consumption patterns of children in other countries where fuel is already scarce. And we can visit and learn from people in the community whose job it already is to conserve energy . . . people at the electric company, the gas company . . . the school custodian . . . the school bus supervisor . . . and others.

The possibilities for learning by doing and seeing for ourselves are limitless!

CAUSES

Man's ability to control and develop energy sources has helped to make civilization possible. To save civilization, he must now buy time for finding new energy sources by conserving the fossil fuels that are left.

QUESTIONS TO GUIDE YOUR READING

What two categories combined take over half of the American family's energy budget?

What fraction of all American workers have jobs associated with the automobile business?

When will nuclear power begin to make major contributions to our electrical supply?

What is called *secondary energy*?

Why is it called *secondary energy*?

How did we waste substantial quantities of our natural gas reserves?

What do we need to get to an era of energy abundance? (one word)

CAUSES

From early man to the present, progress can be recorded in one way as a series of technological jumps—each one directly related to energy use. Man's control of fire with wood as the primary fuel permitted him to cook and preserve food, to live in an otherwise inhospitable environment. With coal, a more concentrated energy source, he could develop manufacturing and expedite trade via steamships and railroads. Oil and natural gas gave him added mobility and opened new prospects for chemical technology. Nuclear energy already has permitted significant advances in medical diagnosis and treatment (through X-rays); it has only begun to be realized as a portable source of power capable of making the deserts bloom and powering spacecraft. Concepts unheard of only a few years ago—such as fusion, utilizing the almost limitless hydrogen of the oceans as a primary energy source—are now nearly within the realm of technical feasibility.

We may be on the threshold of an era when the ability to use almost limitless energy will be shared by all mankind. But what is needed to cross that threshold is time, and that's what we're running out of. Man is literally in a race with himself. As teachers, we have the opportunity and the responsibility to help make sure that tomorrow's citizens understand the implications of the race.

We are running out of time because we are exhausting our fossil fuels on which we have placed great dependence. It is with these fuels that we heat our homes, cook our food, operate our factories, and turn the wheels for moving people and products. These fuels have powered the auto age and the beginnings of the space age.

A noted geologist* has described the situation:

> *When the first settlers landed on the eastern shore of this continent, they were confronted by a forest that came down to the water's edge. Since wood was the basic fuel for both heating and cooking, they must have been encouraged by the seemingly inexhaustible supply of firewood. This could have been the origin of the American attitude toward energy resources—namely—our resources of fuel are so huge as to be virtually inexhaustible.*
>
> *As the population pushed westward into Pennsylvania and western Virginia, coal was discovered. Exposed on hillsides and in stream valleys, coal seemed to be everywhere.*
>
> *Then in the mid-1800's, well before the outbreak of the Civil War, oil was discovered in western Pennsylvania. In rapid succession, oil was found in New York, Ohio and West Virginia. In the early 1900's, the search for oil moved to the mid-continent and then southward into Arkansas, Louisiana and Texas. Also, oil seemed to be almost everywhere.*
>
> *Natural gas poured from the oil wells in such enormous quantities that there was nothing to do but burn it at the well; the night sky was lit by hundreds of oil-well flares. We didn't know what to do with it, so we wasted it. The bountiful flow of oil and this unusable oversupply of gas added to the American conviction already established—we have vast energy resources. First it was wood, then coal, then natural gas.*
>
> *But our convictions were based on assumptions, not on facts. We could, and did, cut down the trees faster than they could be grown. We were mining coal as fast as we knew how, until the pace was slowed by the arrival of cheaper (and less polluting) oil and natural gas. Then oil field after oil field was depleted. Not that all the oil had been recovered . . . But enough had been removed to lower the reservoir pressures, and now the oil would not flow into the wells, and the recovery of the remaining oil could cost more than it was worth. We were running out of cheap oil.*
>
> *Gas fields gradually gave up their reserves, and the search for new gas deposits was pushed (but not energetically) . . .*
>
> *To make up for the shrinking supplies at home, the oil and natural-gas companies increased imports from abroad. And all the time these critical developments were going on, there were few words of warning, or even caution . . . We were on an unprecedented energy outlay . . . Then came the oil embargo of late 1973.*

---

*Richard J. Anderson, Battelle Memorial Institute.

Clearly, we are living on an earth which is limited in its capacity to satisfy our enormous demand for energy supplied by fossil fuels. We must stop using energy which is fed from these sources as if they would last forever.

Energy is consumed almost equally in the major sectors of our national economy: transportation, residential/commercial, and industrial. Electricity generation accounts for one-fourth of our energy consumption. Electricity is often called secondary energy, for it requires conversion of a primary energy source such as coal, petroleum, nuclear fission, or hydropower for its generation.

Americans have more than doubled their total energy consumption in the last 25 years. Demand for energy, per capita, has increased by 50 percent in that time. Clearly, our use of energy extends well beyond our *needs* into the limitless category of *wants*.

How much energy are we really consuming? The following table shows the 1973 energy budget for the average American family, when each family spent about seven percent of its income on energy. Gasoline for the family automobile(s) accounted for over a fourth of the average family's energy outlay, exceeding the expense of home heating. Americans spent almost 17 times as much for energy to operate automobiles as on public transportation.

Consider our affair with the ever-present automobile. The roughly 100 million cars in this country—almost 50 percent of the world total—consume more than 75 billion gallons of gasoline in

Energy Use in the United States Today, by Sector (1971)

	Percentage of Total Consumption	Major Source(s)	Examples of End Uses
Transportation	24	Petroleum and petroleum products (95%)	Moving our vehicles—automobiles, trains, planes, ships, trucks.
Residential/ Commercial	20	Natural gas (40%) Petroleum (40%) Electricity (15%)	Space heating and cooling, water heating, cooking, refrigeration, air conditioning, lighting, clothes drying, running appliances (for homes, stores, offices).
Industrial	28	Natural gas (45%) Petroleum (25%) Coal (20%) Electricity (9%)	Operating machines to produce wide array of manufactured goods.
Electricity Generation	28	Coal (55%) Natural gas (20%) Hydropower (10%) Petroleum (10%)	Electric power plants generate electricity for other sectors (less than 50% efficient); electricity generation not an end use.

Source: Dupree and West, *United States Energy Through the Year 2000.* U.S. Department of the Interior, 1972.

Annual Household Energy Budget for Average American Family (Mid-1973)

Energy End Use	Form of Energy	Percent	Equivalent Amount of Gasoline (gallons)
Automobile	Gasoline	28.2	911
Space Heating	Natural Gas, Oil & Electricity	27.8	897
Major Appliances	Electricity	2.7	88
Water Heating	Natural Gas, Oil & Electricity	6.2	201
Air Conditioning	Electricity	1.6	53
Lighting & Other Electrical	Electricity	1.4	46
Cooking	Natural Gas & Electricity	1.9	60
Miscellaneous Household & Recreation	Gasoline	0.6	20
Public Transportation (Intercity, Nonbusiness Trips)	Jet Fuel, Diesel & Electricity	1.7	54
(Intracity Trips)	Diesel & Electricity	0.1	5
Waste Heat, Electricity Power Generation	Coal, Oil, Natural Gas & Nuclear	21.8	704
Refinery Loss in Gasoline Production	Petroleum	5.9	192
	TOTALS	100	3,231

Source: *Citizen Action Guide to Energy Conservation.* Citizens' Advisory Committee on Environmental Quality, 1973.

traveling more than a trillion miles a year. One out of six working Americans has a job associated with the automobile business. The total annual energy used by passenger cars in the United States (including fuel consumed, losses in petroleum refining to make gasoline and oil, energy used in manufacturing, and repairs) is equal to nearly 150 billion gallons of gasoline or one quarter of gross national energy consumption. While transportation energy consumption in most other countries is primarily for hauling *goods*, in the United States it is primarily for hauling people. In the chart below, originally published in early 1974, the U.S. Office of Science and Technology has plotted this dramatic fact.

Three decades ago, Ohio, like many other states, was interlaced by a system of interurban railroads. These railroads provided cheap, reasonably convenient transportation between population centers. Where are they now?

As the cheaply fueled automobile became America's people mover, our patterns of living, going to work, and shopping changed. Attempts to replace the auto with public transportation have not been successful. No longer do we walk to the grocery store; we drive to the shopping center. There are signs that some of us are rediscovering the bicycle. However, many people still would rather take the family car to recreational areas rather than walk or put up with the inconvenience of a bus.

The fact of the matter is that we are so accustomed to using abundant, cheap energy that a sincere national conservation effort will have to be a trying one.

It is true that, with six percent of the world's population, Americans now consume one third of its presently available energy. However, the substitution of mechanical energy for muscle power has traditionally been a source of national pride in a world that acclaimed inventiveness, technology, and a high standard of living.

In the midst of plenty and the exhilaration of discovery, we have come to depend almost exclusively for energy on exhaustible, nonrenewable fossil fuels. The fossil fuels in the earth now are, for practical purposes, all that we will ever have. This dilemma is at the heart of man's current energy problems.

Alarmed by the present situation, some of us are taking the attitude that this has been wrong. We lose sight of what can be done to

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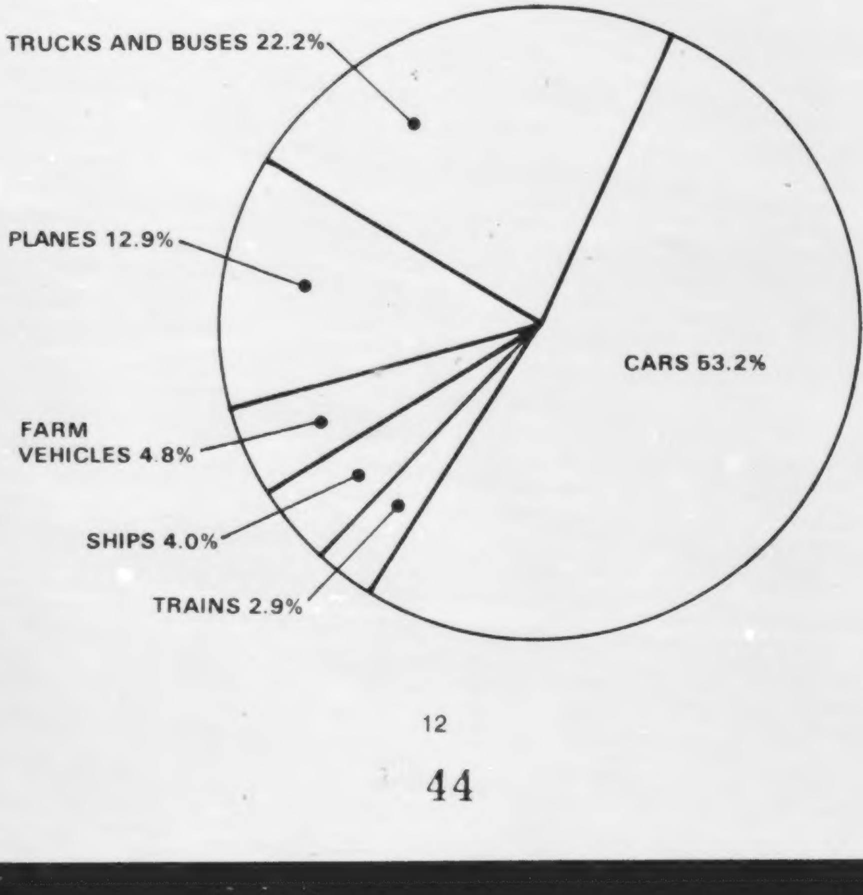
Transportation Wheel of Energy Consumption in the United States



make the world a better place through the constructive use of technology. If new power sources can be developed, there is no reason to believe that we cannot retain the truly meaningful parts of our technology and continue to spread the advantages of mechanical power to other countries. But until we have new sources, we must live prudently.

Some of today's best science students will be helping design more efficient energy conversion systems. Meanwhile, we must make do with machines which are notoriously wasteful in design. This waste is illustrated by the average automobile engine, which operates at less than 30 percent efficiency. A home oil furnace is 65 percent efficient. An industrial gas turbine is only 35 percent efficient. A steam turbine is less than 50 percent efficient in generating electricity, and when that electricity is transmitted long distances, there are substantial losses from the power lines. Prudent operation of mechanical devices can minimize heat losses—whether the heat goes up the chimney, into the cooling water of a power plant, or is lost by friction in the brake linings of the family car.

Well worth remembering are these seven thought-provoking energy shortage facts:

(1) No single "new" source of energy is going to materialize suddenly and rescue us from today's shortages.

(2) It will be 1977 or 1978 before the Alaskan pipelines are finished to bring us oil and natural gas from Prudhoe Bay.

(3) It will be 1979 or 1980 before new gas or oil deposits can be found off the Atlantic and Pacific coasts of the United States and brought into production, if indeed they actually exist there, and if they can be recovered without disastrous effects on the environment.

(4) New plants to produce synthetic natural gas or synthetic fuel for motor vehicles will require at least 3 or 4 years to build, even if we could decide *now* what process to employ. It could be 1982 or 1985 before significant supplies of synthetic fuel begin to circulate through the national distribution system.

(5) Nuclear reactors, on order or under construction, take years to complete. Major nuclear contributions of electricity to the national supply are not expected before 1985. (Today's nuclear share of the national energy budget is less than two percent.)

(6) Advanced nuclear development, such as commercial breeder reactors, could be 10 to 20 years away. Fusion, despite new and encouraging discoveries, is still a hope for the 21st century, not the 20th.

(7) Important additions to the normal energy budget from solar, geothermal, or tidal sources are not expected for another 10 to 20 years.*

These facts lead to an unavoidable conclusion: our only recourse during the next 10 years or more is to increase fuel imports or reduce our consumption. It may be uneconomic to seek *total* energy independence in the very short run. Yet, to increase our imports will mean a growing balance of trade deficit and possible further devaluation of the dollar. The other option is to *conserve* wherever energy is used, not by throwing away our electric toothbrushes (which consume a paltry 6/10,000ths of one percent of our electricity) but by careful and intelligent use of dwindling resources.

*Richard J. Anderson, Battelle Memorial Institute.

WHAT IS ENERGY?

We get our ability to perform work from the sun. Much energy is stored as nonrenewable fuel resources. To conserve these resources, we must eliminate waste . . . particularly waste heat.

QUESTIONS TO GUIDE YOUR READING

How is *energy* defined in physics?

What are the two forms of energy?

What two kinds of energy transformations take place in the sun?

The three types of energy conversion processes are mechanical (physical), chemical, and nuclear (atomic).

(a) In which of these processes is waste heat generated?

(b) Which is the process responsible for all the energy we have?

(c) Which process takes place in a storage battery?

What unit is used commonly to measure potential or kinetic energy?

When a substance is heated, it increases the movement of atoms; therefore, heat is really what kind of energy?

WHAT IS ENERGY?

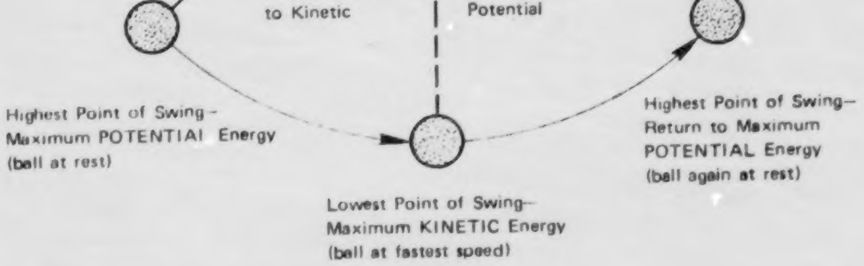
Energy is a word used widely, but often with little thought. There are problems of meaning and problems in scale. *Sheer energy* in a television hosiery commercial may confuse youngsters, nor does it seem meaningful to equate the energy in a popular breakfast food with what the news commentators discuss when they consider new manifestations of the energy crisis (though, of course, food shortages and energy shortages are inexorably related). Frequently, students may be confused and apprehensive, perhaps even turned off. To turn them back on, and provide new awareness, it's practical to introduce energy thinking into other instructional areas, as well as science.* "How did the Pilgrims use energy? What energy sources did you use this morning in getting up and coming to school? What can you do each day to save energy, and how much can you save? What energy sources are used by the school?" These are some of the questions one can ask.

We all know that energy is the capacity or ability to perform work. What, then, is *work*? *Work*, in physics, is a push or a pull (called a *force*) on an object which causes that object to move against a resisting force such as friction, gravity, or simple inertia. Since effecting movement is what we mean by work, obviously play is a kind of work, as are all human actions.

Any moving object is capable of performing work, and therefore possesses energy. We call this energy the *energy of movement* or *kinetic energy*. A rock falling from a cliff into a pool of water has kinetic energy due to gravity. Furthermore, any stationary object also possesses the capacity for moving and performing work, for it, too, is acted upon by gravity, which is opposed by a stronger resisting force keeping the object from moving. The stationary object, such as the rock on the cliff before the fall, possesses the *energy of position* or *potential energy*.

Potential and kinetic are the two states of energy. An object at any given moment is either at rest or in motion; its energy is either

Energy Transformations—A Pendulum


energy changing from Potential to Kinetic
energy changing from Kinetic to Potential
Highest Point of Swing—Maximum POTENTIAL Energy (ball at rest)
Lowest Point of Swing—Maximum KINETIC Energy (ball at fastest speed)
Highest Point of Swing—Return to Maximum POTENTIAL Energy (ball again at rest)

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*For illustrative teaching procedures, see the teaching units.

potential or kinetic. Obviously, work is done only after an object passes from the potential state to the kinetic state, when its stored potential energy is released. A swinging pendulum illustrates the transformations of energy from potential to kinetic and back again.

Several different processes may bring about a change in the energy of an object from potential to kinetic. These processes are either mechanical (physical), chemical, or nuclear (atomic) in nature.

All of these energy state transformations set something in motion which then has the capacity for performing work. The very first process is a nuclear process. The sun is a continuous source of nuclear and thermonuclear energy; it releases energetic nuclear particles and "waves" (photons) which continuously bombard the earth. Much of this energy is absorbed by the earth's atmosphere. Some of it (sunlight) penetrates the atmosphere, where it strikes green plants which convert it to chemical energy by a natural process, photosynthesis. It is this natural process that is responsible for all the fuel we burn. Wood comes directly from green plants. Coal, oil, and natural gas are the fossilized remains of green plants and of plant and animal organisms which consumed them.

When chemical energy is used up, there is no actual loss of matter. That is, the combustion products of coal or oil weigh as much as the fuel did in the first place. But in the sun, matter is actually transformed into energy. And, as we learn from science, the possible energy yield from converting matter is tremendous.

In the sun there are two processes, fission (the splitting of heavy atoms) and fusion (the combining of light atoms). We are beginning to use the fission process directly to produce heat in nuclear power plants. We have produced fusion energy so far only in the hydrogen bomb. Man's hope for ultimate plentiful supplies of energy rests on better control of the fission and fusion processes.

Except in a few cases, such as storage batteries, heat is always generated as an intermediate step between chemical energy and mechanical energy. Heat causes air, steam, or some other gas to expand, and the expanding gas sets something in motion. In nature, a cloud may be set in motion. In man's environment, the heat can be used to drive a piston or turn a wheel. No mechanical device even approaches being a perfect energy converter; some heat always is lost to the surroundings, and there are other losses when heat is generated by friction.

We get most of our electrical power from mechanical energy, requiring another conversion step and more friction losses. In a storage battery, chemical energy is converted directly into electrical energy but there still is some heat loss. Devices for converting heat energy directly to electricity are being investigated in the laboratory and ultimately may become important assets to energy conservation.

When potential energy is converted to kinetic energy, heat is evolved, plus possibly light and sound. Actually, heat is really a form of kinetic energy due, basically, to the increased movement of atoms in the substance

Processes of Energy Transformation

MECHANICAL (physical)	Force pushes or pulls on an object causing it to overcome resistance and move. Origin of force may be man, other animal, plant, wind, water, machine, heat, gravity, magnetism.	Examples:	bowling ball strikes pins; plant pushes up through soil; tornado uproots tree; milk is poured on cereal; toaster pops up toast.
CHEMICAL	Two or more substances brought into contact under certain conditions cause reaction which moves something (often expansion due to heat generated).	Examples:	effervescent tablet fizzes in water; cake rises in oven; match burns when struck.
NUCLEAR (atomic)	Tremendous potential energy holding atomic nucleus together is transformed to heat and light and great expansion of air. Some matter is transformed directly to energy. Two processes: (a) fission or splitting of nucleus by bombardment with subatomic particles; (b) fusion or joining of two nuclei under great heat and pressure.	Examples:	nuclear power plants, "atomic" submarines, atom bomb (all fission); sun's surface, hydrogen bomb (fusion).

that is heated. Because heat is a result of every energy transformation, and because any energy source can be converted into an equivalent amount of heat, the measurement for heat—the British thermal unit (Btu)—is used commonly to measure potential or kinetic energy. One Btu is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. There are about 13,000 Btu in a pound of bituminous coal, 1,032 Btu in a cubic foot of natural gas, 132,000 Btu in a gallon of gasoline, and 145,000 Btu in a gallon of home heating oil.

When one state or form of energy is derived from another, we have *energy-to-energy conversions;* these are happening all the time around us (and even inside of us). The one important thing to remember is that you get only as much out of an energy-to-energy-conversion as you put in; only the forms or states of energy are changed when energy is converted from one form to another. There's no such thing as getting something for nothing.

Of all energy conversions occurring all the time, only a very few will result in work useful to man. We increase the number of conversions that generate useful energy through converters called *machines,* which transform energy of one form, the *fuel,* into energy of another form, the *product.* An automobile engine converts, by burning, the fuel gasoline, a form of stored chemical energy, into the mechanical energy of motion. Our own bodies convert food into movement, heat, and all life processes. The excess heat and sound generated by an automobile engine are mostly waste energy, not useful to our purpose of moving from place to place.

The term *efficiency* of a conversion process or a machine refers to the ratio of useful product to the total amount of input (or output). As users or converters of vast quantities of energy, we are therefore concerned not only with the supply of energy available to us, but equally with the efficiency of our energy-conversion processes.

Electricity is clean, available instantly, and easily transmitted. Since 1950, generation of electricity in this country has increased by a factor of four. However, both the generation and transmission of electricity involve some waste energy. Generation of electricity—the conversion of fuel to electrical energy—is less than 50 percent efficient in even the most modern plants. In many of the older plants as much as two-thirds of the energy generated is lost as waste heat which is exhausted as "thermal pollution" through plant stacks and cooling water. Ten percent of the electricity actually generated is lost during transmission. Newly developed and costly means of transmitting electricity through chilled underground cables have the potential of reducing this loss measurably.

We have seen that all energy conversions —and all our sources of energy—can be traced back to nuclear energy in the sun. Man is only beginning to make use of nuclear energy conversion processes on the earth. The fuel that is presently available for these processes (an uncommon form or isotope of uranium called U-235) is limited in extent and costly to obtain. Other potential fuels for nuclear *fission,* the splitting of heavy atoms, are more plentiful, but they will require many years of technological development. Potentially, the fuel for thermonuclear *fusion* is as abundant as the hydrogen in the oceans, but realistic fusion power may have to wait for the 21st century. This leaves nonrenewable fossil fuels—coal, oil and natural gas—as today's principal energy sources. (Hydroelectric power and other nonfuel sources account for only a small part of our energy budget.) We must simultaneously conserve our remaining fossil fuels and learn how to use them as efficiently as possible.

ENERGY SOURCES

Coal is the only fossil fuel still widely abundant in the United States, but there are problems associated with mining and using it. Ohio is a major producer, but Ohio coal is high in sulfur content.

QUESTIONS TO GUIDE YOUR READING

Uranium, green plants, coal, natural gas, sunlight, fuel oil, oil shale, and hydropower are sources of energy.

(a) Which of these sources are renewable or continuous?

(b) Which of these sources are nonrenewable or exhaustible?

What are the three principal fossil fuels?

Which of the fossil fuels is most abundant in Ohio?

What percent of U.S. energy comes from petroleum and natural gas?

Ohio supplies what percent of the petroleum that is used in the state?

At the beginning of the 20th century, coal supplied about 90 percent of the nonrenewable, inanimate energy in the United States. How much does it supply now?

How many million tons of coal each year (half of U.S. production) come from deep underground mining?

The remaining U.S. coal production each year comes from what type of mining?

What is the principal disadvantage of Ohio coal?

ENERGY SOURCES

Some energy is obtained from sources directly related to the flow of heat and light from the sun. We can term these sources, cautiously, *renewable* or *continuous* energy resources. As long as the sun rises every morning, its energy will be available and constantly replenished.* The amount of solar energy received daily by two square miles of the earth's surface equals the energy released by burning 7,000 tons of coal, or the daily energy output of Hoover Dam. However, we lack the technology to store most of the sun's energy; if we knew how, a year's supply of energy for the world could be gathered from sunlight reaching the earth in three hours and 12 minutes. As a source, solar energy is presently very costly, but extremely valuable. What is needed is an inexpensive means of converting solar radiation to useful energy.

Other energy sources which owe their existence ultimately to energy from the sun and the earth's formation are stored in a kind of "potential energy fund." Their supplies have finite limits and, in most cases, are not being replenished. They are *nonrenewable* or *exhaustible* energy resources.

We call these *fossil fuels* because they were formed from animal and vegetable matter that collected at the bottom of ancient seas and in swamps millions of years ago. This debris was buried by inorganic residue and subjected to great heat and pressure as well as bacterial and chemical action. The end products—oil, natural gas, and coal—contain large quantities of stored solar energy in the form of hydrocarbons.

We can make several generalizations about the *fossil fuels* which account for more than 95 percent of the inanimate energy supply in our state.

- All are found primarily within the earth and extracted at great cost. This means expensive exploration to locate them (except for coal) and large investments of capital to extract them (especially in the case of off-shore petroleum and coal).
- All are storable and transportable—petroleum by pipeline, tanker, barge, truck and rail; natural gas by pipeline (liquefied natural gas by special tanker and barge); and coal by rail and slurry pipeline.
- Oil and coal have important nonfuel uses as raw materials in production of plastics, lubricants, and the like. In the future, many experts feel that coal may actually be better suited for (and could be more efficiently used in) such nonfuel capacities (nonfuel use of coal now accounts for about five percent of the total use).
- Because of their location, composition (especially when high in sulfur), and the process by which they are converted, coal, and to a much less extent, petroleum and gas, require an alteration of the landscape in their extraction and can release pollutants into the air and water when produced and used.
- They are all largely burned, releasing heat energy to perform work.
- All are nonrenewable.

Early in his development, man learned to control the release of stored solar energy through fire. By learning how to use this basic chemical reaction, he became the only species capable of controlling its own environment. Later came agriculture, the domestication of animals, and the harnessing of the kinetic energy of winds and falling water, sails, windmills, and water wheels.

For several centuries, two kinds of renewable energy sources—wind and water—and two kinds of nonrenewable sources (which must have seemed *infinitely* renewable to early users)—wood and coal—vied as the major producers of mechanical work output for civilized man. But the scales became weighted toward coal when the steam engine came into being 200 years ago. (Fittingly, two of the first major uses of the steam engine were to pump water from coal mines and to transport trainloads of coal to factories.) Wind power had its last great days in the 19th century, before the completion of the Panama Canal, when clipper ships brought cargos around the tip of South America.

In the United States, as wood was used up and an expanding population began to demand industrial products, the change to fossil fuels—though later than in Europe—occurred at an accelerated rate. In 1850, coal accounted for only 10 percent of American fuel consumption, wood for 90 percent. But by 1885, coal passed wood, and, by 1910, the situation of 1850 was reversed: coal 90 percent, wood 10 percent. After World War I, petroleum was twice as important as wood, though coal was still predominant. But, by 1946, the petroleum fuels began to outrank coal.

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*A total of 13.9 x 10^{21} Btu reaches the earth daily.

Known for centuries as a product of oil seeps oozing directly from the ground in a few parts of the world, oil was first obtained by drilling in Pennsylvania in 1859. For hundreds of years it had relatively minor use for lighting and heating, but major use in transportation began around 1900. Some 25 years ago, geologists found evidence of large deposits of oil just off the coasts of some lands, under the ocean and under what is called the "continental shelf." Offshore oil drilling offers the major hope for finding new oil to replace diminishing supplies today. But offshore drilling is costly and subject to the possibilities of leakage which can pollute beach areas. Nor is it easy to extract oil wherever it is found. (The "gushers" so often pictured are the rare exception to the normal recovery process.)

Oil does not occur in large reservoirs underground, but rather it is found in the interstices of sand and rock. It is held there so firmly that often no more than a tenth of it will come to the surface unaided by pressure. Frequently, even pumping is not enough because oil is so viscous and the rock is relatively non-porous. Even with best available technologies, only about a third of the oil in any field may be recovered. When water flooding, gas injections, and underground combustion are used, the recovery may be as high as 70 percent, but such high-cost processes may not be justified. The low price of oil has led to waste and has discouraged exploration for new supplies.

Natural gas—previously wasted—began its popularity in the 1940's with the completion of pipelines linking gas fields with user cities. For two decades beginning in 1940, the consumption of natural gas increased at an average rate of 6.6 percent a year, representing nearly two-thirds of the growth in the country's energy production. Gas is clean, and it was cheap, with prices held down by Federal regulations. In the early 1970's, natural gas powered 43 percent of industry and heated and/or cooled the homes of 150 million Americans. Recent Federal regulation changes have encouraged the development of natural gas resources by specifying higher rates for gas from "new" wells than from "old" wells, but because consumption is so great, our gas reserves have an even shorter life expectancy than our oil reserves.

Though available since the American continent was settled, coal still presents problems in mining and exploitation. About 300 million tons of coal each year, half of U.S. production, come from deep underground mining. But deep mining is declining because of costs, job hazards, and poor working conditions. The other half of United States production of coal comes from strip mining, and this half must increase if we are to use coal to fill the energy gap. But strip mining has well-known environmental problems. Another difficulty is that our coal reserves which are low in sulfur lie predominantly in the west, away from centers of population. Although companies are working on anti-pollution measures, technology has not yet found an economical way to remove the sulfur from high-sulfur coal before it is burned.

Coal is the only major fossil fuel which could be utilized more completely in the United States. No industry has a greater opportunity to respond to the energy problem. We have 20 percent of the world's supply; in fact, 89 percent of all our fossil fuel reserves are in the form of coal deposits. We also have relatively large deposits of oil shale; but extracting the oil presents major problems of cost and environmental disruption.

At the beginning of the 20th century, coal supplied about 90 percent of the nonrenewable, inanimate energy in the United States. Since that time, coal production has remained relatively constant but coal's share of the energy budget has dropped drastically. Meanwhile, oil and natural gas have changed places with coal.

Some 77 percent of United States energy now comes from oil and natural gas, and reasons for this are not hard to find. Petroleum fluids are easier to handle and use than coal solids, particularly for cars and other mobile combustion sources. Our massive high pressure gas pipeline network makes natural gas available in most homes; gas heating units are clean, convenient and inexpensive. Oil is the versatile source of a wide variety of liquid fuels and chemicals, and it is relatively easy to remove polluting sulfur from oil. Even with price increases at the pump, gasoline is still fairly cheap. During the 10 years prior to the time of the Arab oil embargo of 1973, gasoline prices increased considerably less than half as much as prices for other consumer items.

On the horizon are ways of synthesizing gas and liquid fuels from coal, of converting underground coal deposits to gas without mining them first. Twenty years ago gas made from coal was widely used in the United States, and the "gas works" with its huge expanding storage tank was a prominent (though not particularly attractive) feature in the urban landscape. The coal gasifier of 20 years ago, originally developed in Germany, is still the only one on the market. Caught napping because of our apparent abundance of natural gas, we have neglected research in coal gasification. Only recently have we begun to mend our ways. And the potential is there, providing we are willing to pay for it. Gasification may ultimately create the biggest new market for coal.

In Ohio, the energy source picture differs somewhat from the national picture. We are fortunate in having abundant coal at a time when petroleum and natural gas are in short supply. But most of Ohio's coal is high in sulfur content, and much of it is economically extractable only by strip mining.

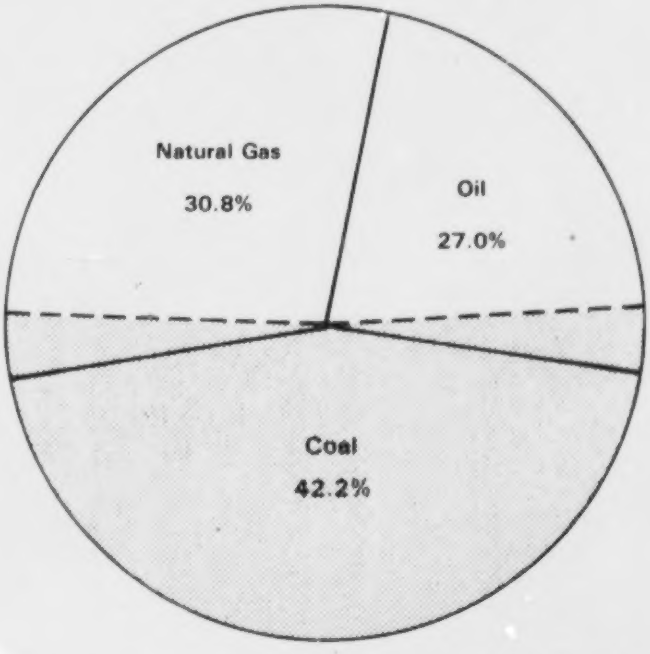
While only two percent of the nation's known recoverable coal reserves are in Ohio, this amounts to more than 20 billion tons of bituminous coal. Ohio supplies roughly 10 percent of the nation's coal and consumes more coal than any other state. Coal satisfies more than 40 percent of Ohio's energy needs, far more than the national average, supplying 95 percent of the fuel for generating electricity in the state.

Ohio uses about the same percentage of natural gas for its energy needs as do most other states—about 31 percent—but can supply only about seven percent of its needs, importing the remainder from other states. Roughly 60 percent of the natural gas is used for residential purposes and 40 percent for industry.

The remainder of Ohio's energy needs are met with oil, 95 percent of which is imported from other states or supplied by companies which rely heavily on foreign suppliers. Ohio's use of oil, which is considerably below the national average, is mainly for transportation.

Ohio's annual consumption of electricity exceeds 106 billion kilowatt hours, placing the state third in electric power consumption, behind only California and Texas. In residential consumption of electricity, Ohio (with 26 billion kilowatts) ranks sixth, behind California, Texas, Florida, New York and Pennsylvania. In commercial and industrial consumption, Ohio (77 billion kilowatts) ranks third, behind California and Texas.

Consumption of Fuels in Ohio (1971)



Shaded areas indicate portions of Ohio fuel consumption which could be supplied by the state's resources, assuming present levels of production (less than 7 percent each for natural gas and oil, 100 percent for coal).

Source: U.S. Department of the Interior.

Less than 10 percent of this country's energy consumption is presently supplied by three nonfossil fuels hydropower—a renewable, continuous source; wood—a questionably renewable one; and nuclear fission—a nonrenewable, highly controversial one. Such renewable sources as wind power and solar heating are as old as civilization. Their present use is minimal, but their potential is great. (They will be dealt with in the next chapter.)

Why we have changed from one energy source to another is an interesting topic for discussion and speculation. Historically, we owe much of our progress to the transition from animate energy sources (horses, human backs) to nonrenewable inanimate ones. Coal replaced wood because it was a more efficient fuel and because wood was becoming scarce. Petroleum replaced coal—even though substantial reserves of coal remain—largely because it is easier to use. In these processes, wind and water power were sidetracked. Water power received some emphasis for generating hydroelectricity, but the lack of availability of sites for hydroelectric power stations imposed a realistic limit. Man lacked the incentive to develop wind power (considered an unreliable source) beyond its early application to windmills.

What will the trend be at the beginning of the 21st century—when today's students will have been making the decisions about fueling America?

Energy may be obtained from the hot interior of the earth. Geothermal energy is largely untapped and additional research is needed to determine how this source may relieve the shortage.

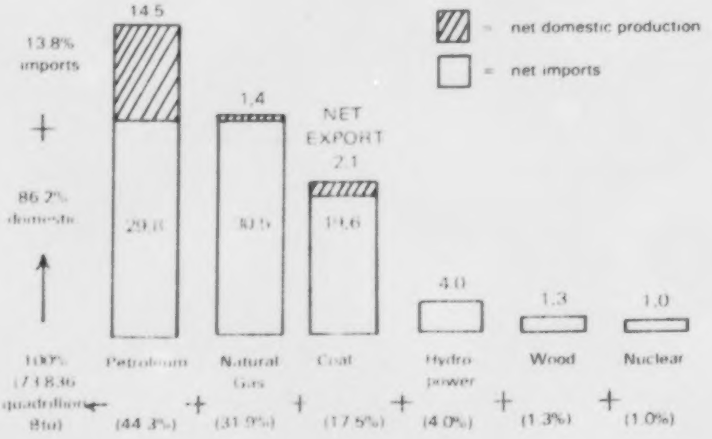
The movement of water has long been a useful energy source. Although its use in an earlier day was readily apparent in grist mills located by rivers, it has never provided more than four percent of our needs even as hydropower. At some future date, water may be a more useful source. Investigations are being conducted to determine the feasibility of extracting large amounts of energy from ocean waves.

Shale comprises a resource base for oil extraction. Deposits are mostly located in government lands in Colorado and Wyoming; these areas may prove of value in the search for additional oil.

The nuclear source of energy is of significance in part because this nation has the greatest low-cost uranium reserve in the free world. Extraction of this source is costly and the by-products of its use create a disposal problem, but its availability in large amounts will compel further investigation of nuclear energy's potential to help alleviate the shortage. Potentially, thermonuclear fusion has an almost limitless fuel supply—hydrogen. But there must be a major scientific breakthrough before fusion power can be considered seriously.

For the short term, our reliance would seem to be on oil and gas. For the long term, we will be looking to coal and atomic power. With large United States reserves, coal would appear to see us through the first quarter of the next century. For any lasting relief, we must hope that practical means can be found to tap hydropower, solar radiation, winds, tides and geothermal sources on a large scale. In the immediate future, the hope for alleviating shortages lies with reducing demand.

United States Energy Consumption by Source—Mid-1973



Source: Citizen Action Guide to Energy Conservation, 1973

MAJOR ENERGY SOURCES

	PETROLEUM	NATURAL GAS	COAL
Composition/ Origin	Hydrogen and carbon formed from tiny marine organisms and plant matter buried under ancient seas, under great pressure.	Methane; petroleum (natural gas liquids are also formed). May be liquefied at cost for easier transportation by tanker, truck.	Varied composition – mostly carbon, some hydrogen, varying amounts of sulfur; formed from plant remains buried under ancient lakes and bogs under great pressure; three types, of increasing age and hardness, are lignite, bituminous, and anthracite.
Location	Underground "reservoirs", petroleum trapped in interstices of sand and rock, largely Texas, Oklahoma; off-shore under Continental Shelf (Louisiana, Texas, southern California). Large untapped deposits in northern Alaska.	One-half is found wherever petroleum is found and one-half is found in underground rock (especially southwestern and south central states). Forms "cap" on petroleum deposits and provides pressure to aid petroleum extraction.	At varying depths from just under surface to far underground; found in 27 states.
Extraction/ Conversion	Wells drilled up to 25,000 feet depth; 15% of reservoir of petroleum rises to surface because of underground gas and water pressure; pumps remove 15% more; another 20% may be recovered but at a much higher cost. Crude petroleum is refined through separation into fractions at different boiling points. From chemical modifications and blending of the fractions, products are given the desired characteristics.	Removed by wells; rises to surface under pressure; some is found with petroleum; some is found alone. Natural gas is treated to remove heavy hydrocarbons and hydrogen sulfide, which can be used by the petroleum and petrochemical industries.	Underground mines (only half of coal in a deposit is recovered) and strip- and open-pit mining where surface earth is removed and coal cut and shoveled out by machine. Sizing, washing and cleaning for traditional combustion uses. Conversion to synthetic natural gas and liquefaction by treatment with hydrogen are in the demonstration stage.

MAJOR ENERGY SOURCES (Continued)

	PETROLEUM	NATURAL GAS	COAL
Uses	60% transportation (largely refined as gasoline, diesel fuel), 20% residential/commercial heating, 10% electrical generation.	45% industrial fuel, 35% commercial heating, 10% electrical generation.	65% electrical generation, 30% industrial.
Advantages	Easy to use, store and transport; ideal fuel for transportation industry.	Cheap, clean, easy to transport.	Cheap, large reserve, Appalachian sources close to large markets.
Disadvantages	Domestic supply has declined in recent years; increase in usage requires increased foreign exchange; refining of high sulfur crude can cause pollution.	Difficult to store; increasingly in short supply.	Expensive to transport. Ash disposal and fly ash out of the stack cause pollution. Combustion of high-sulfur coal releases sulfur dioxide. Low sulfur western coal is distant from large markets. Underground mining is a hazardous operation unless elaborate precautions are taken. Surface mining (strip mining) causes environmental problems unless expensive reclamation is undertaken.

MINOR ENERGY SOURCES

	HYDROPOWER	NUCLEAR FISSION	WOOD
omposition/ Origin	Water impounded in dams; tidal water area potential resource.	Uranium and thorium ores.	Trees, wood waste; agricultural waste.
ocation	Often in remote and mountainous areas.	Ores are found in Colorado Basin, Canada, South Africa, Zaire, India.	Areas often remote from large population centers.
xtraction/ onversion[1]	Water turns turbines producing electrical energy. (Virtually all hydropower is converted to electricity.)	Chemical processing concentrates ore; enrichment of desired isotopes by physical means, e.g., gaseous diffusion. In nuclear reaction, nuclei of heavy atoms of "fissionable" isotope are bombarded by neutrons causing nuclei to split, converting the matter to great quantities of heat. Fission of one atom releases neutrons causing a chain reaction, splitting other atoms in a controlled process. Turns water to steam to drive turbines and produce electricity.	Trees are grown, felled and collected at wood or crop processing centers. Burned for heating and cooking in some places.
Uses	100% electrical generation.	100% electrical generation.	50% heating homes 50% industrial (scrap) 34 million cord in 1975

MINOR ENERGY SOURCES (Continued)

	HYDROPOWER	NUCLEAR FISSION	WOOD
Advantages	Efficient, little waste heat; inexpensive, renewable energy; may be conserved through pump storage; environmental effects generally slight; reservoirs may enhance recreational value of area.	Heat value of one ounce of U235 equal to 388 barrels of petroleum. Very rapidly growing as an energy source – the "energy source of the future."	Availability; wood is renewable, given time to grow new forests.
Disadvantages	High capital construction costs; requires very special location, few good sites remain; may flood land better used for other purposes (agriculture); evaporation rate high in arid lands.	Controversy over harmful effects of radiation leakage into surrounding area from unlikely, but still possible, accident; possible leakage from radioactive wastes; the common "light-water reactor" requires large quantities of water for cooling – recycling water into lakes or rivers may result in thermal pollution. U 235 is scarce – new breeder reactors may alleviate problem.	Low heat value per unit volume; non-fuel uses more important; only practical in certain locations.

ENERGY SOURCES FOR THE FUTURE

SOURCE	HOW CONVERTED	COMMENT
(Fossil Fuels)		
Oil Shale	A sedimentary rock which contains "kerogen", a substance that, when heated, yields shale oil; would likely be used as substitute for oil.	Present in huge quantities in Rocky Mountain states (estimates from 600 billion to 3 trillion barrels of oil). Adverse environmental effects of extraction by open-pit mining. Large quantities of shale required for small yield of oil (one ton of shale yields 30 gallons or less petroleum). Problem of waste disposal.
Tar Sands	Contain extractable petroleum substance.	Large deposits only in remote areas. Major supply in North America in Athabaska, Canada, frozen and difficult to extract and transport.
Coal Gasification	Coal reacted with steam followed by further processing produces synthetic natural gas (SNG).	Coal is plentiful, but the cost of processing plants is great ($500-$800 million). SNG is a clean and desirable fuel. New coal mines are needed.

ENERGY SOURCES FOR THE FUTURE (Continued)

SOURCE	HOW CONVERTED	COMMENT
(Natural Continuous Sources)		
Geothermal	Natural steam underground rises to surface with enough force to drive turbogenerators for electricity.	Clean, inexpensive energy. Used in Italy, Iceland, Japan, New Zealand, in the U. S. at the Geysers near San Francisco and California's Imperial Valley, with potential sites throughout western United States. Little natural steam exists underground. However, much heat in underground rock layers could be tapped by pumping cold water down to the rocks and retrieving heated water. Limited to local use in a few favorable locations. Problem of brine deposits clogging and corroding pipes. Surface pollution problem from New Zealand underground waters.
Solar	Collectors over a vast area focus sun's rays on a liquid which can conduct the heat to an electrical generating plant; or solar cells over vast area convert sunlight directly to electricity. Space heating.	An immense energy source. Little environmental effect except that large amounts of open space would likely have to be devoted to collectors to gather the diffuse energy of sunlight. Location would seem restricted to areas of great sunlight far from population centers in this country (drawback because of extent to which electricity is dissipated during transmission). At present, most important in home heating and water heating in specially designed houses.
Tidal	Same principles as conventional hydropower — rise and fall of tides rotate turbines to generate electricity.	Very efficient. Requires very special locations; few exist in North America and those that do, such as the coasts of Maine and Alaska, are remote from population centers. Difficult to make energy supply continuous.

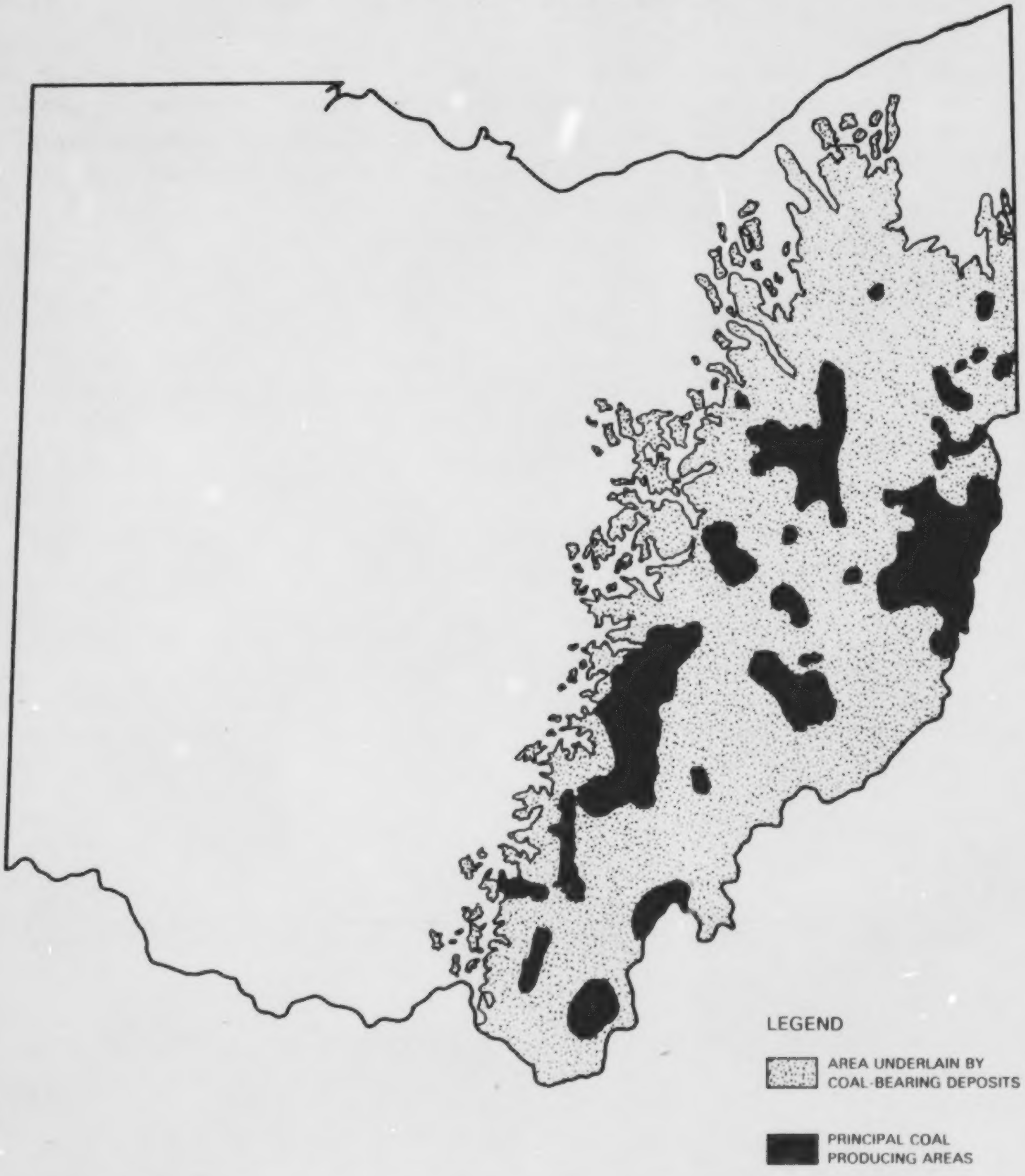
ENERGY SOURCES FOR THE FUTURE (Continued)

SOURCE	HOW CONVERTED	COMMENT
Wind	Same principles as hydropower – running air propels turbine to generate electricity.	Clean, neat, inexpensive. Very efficient. Location important – proposals generally for windmills on platforms in Great Lakes or on Atlantic Ocean. Better as local source in certain conducive areas. Sufficient wind for continuous generation unlikely.
(Other Sources) Hydrogen	Burning hydrogen for heating as with natural gas.	Most abundant element in universe, although extraction of hydrogen from compounds can be costly. Reactions between liquid hydrogen and liquid oxygen powered NASA rockets. Clean – only waste product is water. Drawbacks – dangerous to handle; one-half the energy content per volume of natural gas.
Fuel Cells	Battery-like, portable electric generators produce current from reaction of hydrogen and oxygen.	Little pollution, no noise, much more efficient in generating electricity than conventional generators. Drawback – very costly because of short life. Have been used only in space program.
Magneto-hydrodynamics (MHD)	Converts heat from combustion gases from coal directly to electricity by passing gases through magnetic field. Uses coal as starter fuel. Represents new kind of generator converter.	As an alternative to conventional coal-fueled power plants, MHD eliminates most air pollution, requires less fuel, is 1½ times as efficient (very little waste heat). At present many technical problems and little support for research. More research being done in USSR and Japan than in U. S.

ENERGY SOURCES FOR THE FUTURE (Continued)

SOURCE	HOW CONVERTED	COMMENT
Burning of Trash	Burning combustible trash, in mixture with coal or other fuel, to power electric generator.	Cheap, readily available fuel. Conventional combustible garbage possesses 50% of potential heat of coal. "Solves" garbage disposal problem. Although the air pollution problem remains, the waste disposal problem is alleviated. City of St. Louis currently getting some electricity from power plants fueled by garbage and coal. Trash must be carefully sorted.
Nuclear Fission (breeder reactor)	Uses U235 as "starter" to bombard surrounding atoms of nonfissionable U238 and convert it to Plutonium 239 which is fissionable, "creating" more starter.	Uses less scarce U235 than present light-water reactors. Some plutonium is produced directly in light-water reactors. Is cooled by liquid sodium (difficult to handle). Possibility of accident, especially during transportation of wastes, more of a concern with plutonium than with uranium. Technological difficulties.
Thermonuclear Fusion	Fusion of atoms of hydrogen to form heavier atoms of helium under extremely high temperatures (100 million degrees C) in a controlled reaction (as opposed to the uncontrolled fusion reaction of a hydrogen bomb.)	Hydrogen is very abundant. Ordinary seawater could be used as source of fuel. Very efficient reaction. Releases only small amounts of radioactivity. However, it is technologically very difficult to achieve a controlled reaction at present levels of technology and knowledge.

Ohio Coal Producing Areas


LEGEND
AREA UNDERLAIN BY COAL-BEARING DEPOSITS
PRINCIPAL COAL PRODUCING AREAS

Source: Ohio Chamber of Commerce.

SEARCHING FOR SOLUTIONS

As America seeks to become energy self-sufficient once again, we develop new sources ranging from better nuclear power generators to huge solar collectors. But the lack of time compels us to conserve and recycle the energy resources that we can use today . . . not in the next century.

QUESTIONS TO GUIDE YOUR READING

What happened in November, 1970, that gave us cause to worry about our future oil supply?

By 1972, what fraction of our U.S. oil heritage of 200 billion barrels was gone?

What percentage of known petroleum reserves is located in the Middle East?

How many million tons of trash, potentially burnable in power plants, do Americans throw away each year?

Newspapers, potentially, are good candidates for recycling. What are two reasons why this isn't done more widely?

What factor will encourage the development of new energy resources?

What is the government program for national energy self-sufficiency called?

SEARCHING FOR SOLUTIONS

In 1972, Representative Chet Holifield of California said, "What this country needs to dramatize our energy crisis is a good 24-hour blackout."

We've come a long way since then, and there are few of us who do not realize that conserving energy and our country's future are inexorably related. Some of us even have stopped complaining about driving 55 mph to save gasoline! But, lest we become panic stricken, this is a time also for concrete solutions rather than desperate measures.

Oil and natural gas became the most widely used fossil fuels in the United States because we drew on our own resources, not those in the Middle East. In fact, we may remember the prophets of doom some years ago, who kept saying that the United States was running out of oil. Yet, new deposits were constantly discovered, and the future somehow was pushed back.

All of this came to a halt in November, 1970, when the *rate* at which we were finding domestic oil reserves failed, for the first time, to exceed the rate at which we were consuming oil. From that time on, the known reserves have declined steadily; we have increased our dependence on oil imports, which have tripled in the last 25 years. By 1972, about half of our known oil heritage of 200 billion barrels was gone, and the rest was becoming increasingly hard to get.

As oil imports increased, we became more dependent on foreign reserves, joining the nations of Western Europe whose petroleum reserves are considerably smaller than ours. We turned to the Middle East, source of 53 percent of known petroleum reserves, as well as to Latin America, which traditionally had made up our oil deficits. The activities of the oil cartel and the effects on our foreign trade and balance of payments are well known. As a result, the government, through Project Independence, has opted for national energy self-sufficiency by 1985. This project is a blueprint outlining the size and shape of our problem and recommending self-sufficiency as a national goal.

It is hoped by 1985 that it will make economic sense to "buy American." By that time, we may have curbed our energy appetite, which by 1970 was doubling every 10 years. We may also have developed new energy sources through research and better utilization of traditional sources such as coal.

Several trends justify a cautious optimism. We have realized that the environment is fragile and in some aspects irreplaceable, and technologies are being developed to harvest energy resources without as high an environmental cost as has been paid in the past. Technology is also advancing in the field of recycling, in order to lengthen the life of dwindling resources. Research is progressing on several fronts to harness the energy of renewable sources such as wind, sun and tides. Higher fuel prices are furnishing incentive to explore and develop new sources and conversion techniques.

Economic incentives, probably in the form of higher prices, will encourage searches for new deposits and promote further development of present ones. Such economic incentives will also spur efforts to improve refining and electricity transmission methods to cut down on energy losses.

However, these efforts will not alleviate the central problem. They will simply help us use our finite fossil fuel supply more efficiently. Increased funding for research and development of alternative sources will be needed to bring about the day when they are viable sources.

Surface mining companies can, and do, make efforts to restore mined lands to their former usefulness. Methods can be found for removing sulfur from coal; the key is to find a method that is economically feasible. Automobiles can be designed with smaller, more efficient engines.

Many things are being done to improve our extraction and conversion of energy sources so as to increase supply and lessen the environmental cost. More could be done. They are technologically possible; and they will be practiced increasingly as there is economic benefit to be gained from them in terms of added profits or penalties avoided.

Recycling is a key to extending our present resources until alternative energy sources can be made workable. Recycling includes both the recovery and reuse of natural resources, and extending the life of products. Here, too, a united effort is required. The student must be helped to understand that each of us can make an important contribution if we live conservatively and keep doing so. Meaningful recycling must go far beyond the two-week science project or the occasional paper drive. We must start at home in an unglamorous way by using up what we have or wearing it out.

Ohioans can be proud of the steps toward recycling already taking place in our state. Many city governments are considering the possibilities for burning wastes to supply power. At Franklin, Ohio, there is an experimental *total* waste recycling plant, potentially capable of processing nearly all of the community's wastes for reuse.

Each year Americans throw away 125 million tons of trash, potentially burnable in power plants. Yet, the plants to burn this trash must be highly sophisticated, capable of removing air pollutants and operating with a variety of fuels. The wastes must be collected and brought to the plants in large enough quantities to make the processes economic.

Many of us save old newspapers for recycling, but here also are constraints. Large quantities of water, which may become polluted, are required for recycling paper pulp. And high freight rates make it costly to bring newsprint to a recycling plant even though it may cost less to make paper from recycled stock than from wood.

In many areas our old automobiles and other metal scrap are being almost totally recycled. Yet there still are problems in getting the scrap into sizes and forms in which it can be utilized. Burning the nonmetal parts of old automobiles is highly polluting; removing the copper wire from junked cars takes time. Big machines can chop steel scrap into bite-sized chunks for reprocessing, but these machines require considerable energy.

There are many approaches to new thinking and better conversion methods for recycling; better ways of handling wastes at home and in industry and at all levels of the recycling process. Has anyone ever thought of designing automobiles which, in addition to using gas more efficiently, can be recycled more easily? Questions like this are good discussion starters for all grade levels. How can "tin" cans be recycled? What provisions does your community have for recycling glass? How can we get more use from books and magazines?

As is true for environmental safeguards, the technology of recycling is, as yet, far ahead of the capacity of most communities to practice it on a significant level. One estimate is that large-scale adoption of municipal resource recovery systems is 10 years away. Most present systems consist of some combination of shredders, grinders, scanners, screens, and electromagnets to break down and sort out ferrous metals, aluminum, glass, combustible and noncombustible garbage. Some demonstration plants are developing the capability to yield fuel oil as well.

The economics of large-scale recycling pose more problems than the technology. In addition to a sizable investment in equipment, recycling centers must find markets for the sorted scrap. The overriding economics, however, may well be the savings in energy as well as raw materials. Recycling paper and steel requires 70 percent less energy than manufacturing with new materials.

Although today's energy situation is serious and the forecast is a challenge for survival, there is another side to our energy problems. Our belated realization that fossil fuels are finite may prompt a reversal in our energy use patterns from spendthrift to more thoughtful use. And the change may come soon enough to give us a margin of time in which to find other sources, other use patterns.

CONSERVATION: AN ETHIC FOR EVERYONE

We know we can work together for a common goal if we believe in it. The challenge is to make energy conservation a common experience that we all can share directly.

QUESTIONS TO GUIDE YOUR READING

What should you look for when your students complain they are cold in a heated classroom?

You and your students are planning a field trip, and you will be away from your classroom for the entire day. Turning out the room lights and turning down the thermostats are two possible energy conservation measures for your class. Can you suggest others for the field trip?

In past history, when a society ran out of energy, what could it do?

Why can't we do this today?

CONSERVATION: AN ETHIC FOR EVERYONE

We've seen the story over and over again in the movies and on television. A group of people in a lifeboat have only a little food and water. They divide up the supply, and each one takes just enough. For days they survive, and just at the last minute they are rescued. This is a simplistic illustration, but time and time again history has demonstrated that people will practice conservation and work together for the common good, providing they realize that they all are in the same boat. It is our job to make this realization meaningful to our students. Conservation is not just what one does somewhere else, out in the forests of the American West.

Some conservation measures are being imposed on us from the outside. We must pay more for luxuries, so we consume less of them and, thereby, we save energy. We must remember that society *also* is responsible for finding new and meaningful work for the people who formerly made these products. Higher prices inevitably will slow down energy demands, but in the long run energy conservation—and our very quality of life—must depend on our practice, together, of an energy conservation ethic. Like the environmental ethic already practiced in our schools, this new energy ethic must be with us constantly, interpreted in a way that makes us understand our needs and wants in the context of the world around us. We must all overcome the attitude that, if we can afford it, we should be able to use it. This attitude does nothing to solve the energy waste and conservation problem. Perhaps viewing conservation as energy insurance would help change attitudes and stimulate positive action.

We practice the energy conservation ethic when we understand that fossil fuels are very important to us, personally. How many children today actually know what a lump of coal looks like? How many know what happens when they plug in an electric toaster? Because children and youth are curious about the world around them, they may be far better prepared to appreciate the personal value of energy resources than their parents are. Creating a learning atmosphere in which they can understand and practice energy conservation is a challenge worthy of the personal commitment of every teacher.

For most of us, the changes will not be fundamental ones. We will be slightly cooler in winter, warmer in summer; make our purchases with a view to efficiency and recyclability; rely less on throwaway packaging; drive smaller cars at slower speeds, use public transportation and walk more; turn off lights we are not using; and learn to think of energy as money. We will not need to return to energy-use patterns of a century ago. But we might well return to the spirit of the slogan that was so popular during World War II: "Use it up, wear it out; make it do, or do without."

Most school systems already have worked out energy conservation plans. Every teacher should be thoroughly familiar with the *Guidelines for the Conservation of Energy in Ohio Schools* published by the State Department of Education. They reflect the development of an awareness of the value of energy as a scarce resource. By carefully observing and practicing these guidelines, we can transmit this awareness to our students.

For example, we know that even when air that is heated to 74 to 78 degrees is moved swiftly through a classroom, we can be uncomfortable because the air removes body heat in an excessive way. If we can eliminate drafts and reduce air flow to required standards, we feel much more comfortable at lower temperatures. But many of today's schools were built when there seemed to be energy to burn, so insulation, tight doors and windows were not always given priority attention; you can help correct this, but you may require professional assistance. Similarly, you as a teacher can watch the thermostat, but your school district must make sure that the automatic temperature regulators are maintained adequately and that heating systems are kept up to date.

You might want to consider (depending on your local situation) setting thermostats as low as 55°F near the close of the school day and for the night ... turning thermostats down to 40°

on weekends unless pockets of uneven temperature may cause damage ... shutting off all outside air at the end of the school day and on weekends ... switching from natural gas to an alternative fuel, where possible.

At home there are many possible conservation measures (your students can doubtless come up with a much longer list than this one):

- keeping thermostats down
- providing adequate insulation, weather stripping, and storm windows
- operating dishwashers, clothes washers and dryers only once a day
- turning off lights and televisions and replacing incandescent bulbs with fluorescent fixtures
- washing in cold water and taking showers instead of tub baths
- selecting clothing for wear and durability
- closing draperies at night during the winter and keeping them closed during hot summer days
- walking or riding a bicycle instead of driving (but always practicing *safe* riding habits)
- keeping the family car in tune, with tires properly inflated
- buying and using appliances which are most efficient (consumer magazines can tell you which ones to select)
- using an exhaust fan in the summer to supplant or help the air conditioner
- doing without air conditioning if possible
- taking vacations close to home with the entire family together
- organizing car pools
- and so on.

Most of these suggestions boil down simply to using good judgment, a quality Americans are traditionally noted for.

Nationally and statewide, many energy-saving steps are being taken. Your students can document them; they also can suggest more steps by writing *directly* to leaders in industry and government. We see moves:

- to encourage interest in intermediate technology as compared to placing value on bigness.
- to move toward self-supporting communities with diversified industries to support the needs of the population.
- to stimulate interest in handcrafting and the manual operation of small machines for making products.
- to provide better mass transit through express bus services from suburban parking lots, "dial ride" and pooled taxi services, more convenient transit schedules, renewed interest in trains and interurban lines particularly in high-traffic corridors such as Cincinnati-Columbus-Cleveland.
- to schedule airline flights to 90 percent seat capacity and at times when planes are not "stacked" over airports.
- to cut down on yearly automobile redesign and make it easier to replace fenders, bumpers and other parts.
- to promote nearby tourist attractions.

If these trends are to fulfill their promise, your role as an educator will be crucial. Creative thinking will be at a premium as we seek both short and long range solutions to our energy problems. Both thinking and doing are important, for time spent in teaching conservation is practically useless unless the knowledge is translated into action.

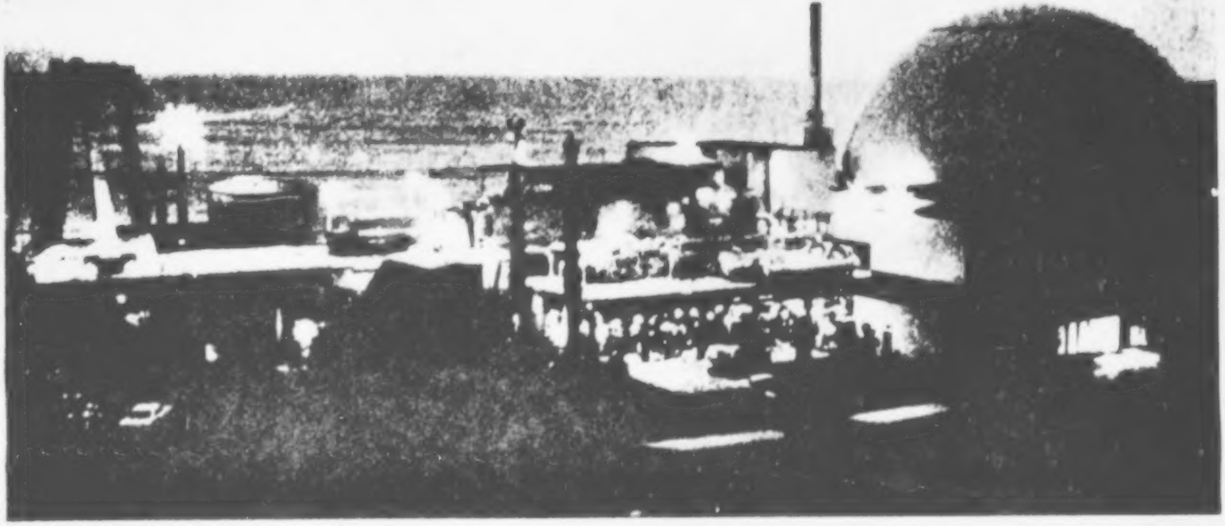
In Ohio classrooms today are the boys and girls who must develop workable ways of protecting and preserving the vital natural environment, if the environment as they know it is to be left for their children. Perhaps one of them also will unlock the technology which will relieve us of our dependence on fossil fuels. Is that student in your classroom today?

Our energy situation is like the status of space exploration less than a generation ago when the Russians surprised us with Sputnik. Suddenly, America needed trained scientific leadership, and it was fortunate that the talents of John Glenn, Neil Armstrong and other leaders were being developed on foundations laid in Ohio schools—foundations in the humanities as well as the sciences.

Since the 1950's, the space program has given us a new opportunity to look at ourselves. The implications to science and mathematics have been obvious, but we also have seen from the perspective of space that the earth has limited resources and that we all are responsible for conserving these resources. The world view that we share through the social sciences and literature already is reflecting this interdependence. Today's students must be the "energy astronauts" of the future. For them, the conservation ethic must become a way of life, reaching into nearly every activity.

Historians would search in vain for a society which has cut back its demands for energy and still flourished. Usually, the historical answer to avoiding extinction has been to conquer new lands to find new energy sources. But there are no more new lands. We are confined to a planet where energy is scarce everywhere. Thus, we lack a historical precedent, but we do have at our disposal the technology and the knowledge to find our way out of this apparent dilemma. The challenge is in communicating the energy conservation ethic and its basic foundations to those who will need this knowledge in order to live.

That is why the outcome rests, to a critical extent, with those who would mold the future in the classrooms of the present.



ANSWERS TO E.Q. QUESTIONS

1. Because they are derived from animal and vegetable remains that collected at the bottom of ancient seas and swamps more than three hundred million years ago.
2. Petroleum, natural gas, coal.
3. Sun, wind, falling water, tides, plants, animals, muscles.
4. Coal.
5. The correlation of the study of energy to science and mathematics is obvious. Social studies trace the advancement of societies in relationship to energy use. Literature tells of the lives of people involved in the development of energy. The basic energy source, the sun, is frequently the theme of much music and art.
6. (1) The fossil fuels in the earth now are, for practical purposes, all that we will ever have. This dilemma is at the heart of man's current energy problems. (2) The demand for energy is ever increasing.
7. As a nation, we are realizing the need to move toward self-sufficiency, and technology is being challenged to discover new energy sources and conversion processes.
8. The automobile and space heating.
9. Over half of the transportation energy in our country is consumed by automobiles, which are used primarily to carry people rather than goods.
10. Because it requires conversion of a primary energy source such as coal, petroleum, nuclear fission, or hydropower for its generation.
11. The turbines which generate electricity are less than 50 percent efficient, and a substantial amount is lost through transmission along power lines.
12. By being burned off at the heads of oil wells before it was learned that gas could be used profitably.
13. In meeting our energy demand, we can either import more fuel or reduce our consumption. Other options are intensified exploration for new reserves, more efficient ways of recovering fuel resources, and discovery of new sources and conversion processes.
14. Energy is the ability to perform work.
15. Kinetic and potential.
16. Fission and fusion.
17. (a) All three.
    (b) Nuclear.
    (c) Chemical.
18. The British thermal unit (Btu).
19. The ratio of useful product to the total amount of energy input or output.
20. Electricity is clean, available instantly, and easily transmitted. However, both the generation and transmission of electricity involve some waste energy.

21. Heat is a kind of kinetic energy.

22. (a) Sunlight, green plants, and hydropower.

    (b) Uranium, coal, natural gas, fuel oil and oil shale.

23. Fossil fuels are found primarily within the earth and all are storable and transportable. They have nonfuel uses and require altering the landscape for their use. All are burned, producing heat to perform work. All are nonrenewable.

24. Coal.

25. Steam engine.

26. Oil and gas are cleaner, easier to handle than coal solids, more versatile, and less polluting.

27. Coal.

28. Gasification.

29. Hydropower, solar radiation, winds, tides and geothermal sources.

30. In November, 1970, the rate at which we were finding domestic oil reserves failed, for the first time, to exceed the rate at which we were consuming oil.

31. National energy self-sufficiency by 1985.

32. Technological advancements are being made in the areas of (1) harvesting energy resources without as high an environmental cost, (2) recycling to prolong the life of dwindling resources, (3) harnessing energy of renewable sources such as wind, sun, and tides.

33. Recycling (1) extends the life of products, (2) cuts consumption of natural resources, (3) reduces litter.

34. Problems in total recycling of throwaway materials are finding markets for the sorted scrap, costs of collecting and transporting it, and energy consumption of machines which sort and process it.

35. Present major extraction and conversion processes exact environmental cost by releasing pollutants and causing damage to the land and bodies of water.

36. Higher fuel prices to furnish an incentive for exploration and development of new sources of energy and conversion methods.

37. An acceptance of the fact that resources, in particular our fossil fuel resources, are finite and therefore precious, to be used wisely.

38. Maintaining lower temperatures and using electricity, paper supplies and other energy consuming materials carefully.

39. Turning off lights and appliances when not in use, keeping thermostats down, buying appliances which are efficient, providing adequate insulation.

40. Providing efficient mass transit, promoting nearby recreational attractions, enforcing lower speed limits, encouraging community planning to decrease commuting distances, enacting standards for more energy efficient cars and appliances, stimulating technological advances in the discovery and development of new sources of energy and means of conversion.

GLOSSARY

British Thermal Unit (Btu)—The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. Because all energy may be converted to heat energy, the Btu is often used as a standard measurement for the "energy content" of many energy sources. As the following table of equivalents shows, the Btu is a very small unit of measurement:

Fuel	Common Measure	Btu Content
Crude Oil	Barrel (bbl.)	5,800,000
Natural Gas	Cubic Foot (cf)	1,032
Coal	Ton	24-28,000,000
Electricity	Kilowatt Hour (kwh)	3,412

(Unfortunately, direct comparisons of energy content of different fuels cannot be made accurately because of the difficulties of measuring them in the same units.)

Coal Gasification—A process by which coal, in contact with steam, can be made to produce a substitute for natural gas.

Conservation—Preservation from loss or waste. With regard to our consumption of energy, the message of conservation means finding the wisest possible use of nonrenewable, exhaustible energy sources and improving conversion processes so as to increase efficiency.

Cycles of Energy Substitution—A way of picturing the history of energy sources in the United States. Wood and coal had completely replaced wind and water as major energy sources around 1870; coal replaced wood as the major energy source around 1885; and petroleum replaced coal as the major energy source about 1940.

Efficiency—The amount of *useful work* we get out of a machine or conversion process divided by the total energy output. Efficiency, expressed as a percentage, also measures the amount of useful energy we get out, divided by the amount of energy we put *into* a machine. We can speak of the relative efficiencies of various fuels or energy sources in a particular conversion process; and we can speak of the relative efficiencies of various conversion processes using a particular fuel. No machine is 100% efficient.

Energy—The capacity or ability to perform work.

Energy-to-Energy Conversions—Changes in states or forms of energy. Most energy is derived from another state or form—kinetic from potential, heat from mechanical, and the like.

Environmental Cost—All forms of energy extraction, conversion, and use exact a toll of our environment. The advantages of a particular energy use must be weighed against its effects on the environment.

Extraction—Retrieval of fossil fuels from the earth.

Fission—A "splitting," specifically the splitting of certain heavy atomic nuclei into two atoms of much lower atomic weight. The loss of mass appears as energy in an amount equal to the difference in mass times the speed of light squared (186,000 miles per second^2), or $e = mc^2$. The process begins with the bombardment of a "fissionable" atom by a neutron of another atomic nucleus which releases neutrons from the "target nucleus." This release enables the process to be self-perpetuating, and *chain reactions* are possible. Controlled, they generate useful energy; uncontrolled, they are an atomic bomb like those of World War II.

Flow or Fund—A useful way of classifying energy sources. Some energy is derived from the continuous, renewable flow of energy from the sun. Other sources are stored from times long past in a nonrenewable, exhaustible energy fund.

Fossil Fuel—An energy source, such as coal, oil, and natural gas, derived from the action of tremendous heat and pressure on animal (chiefly marine) and plant fossils buried under the earth's surface more than three hundred million years ago. Fossil fuels contain the stored chemical energy of plants and animals that were once alive.

Friction—Resistance to motion of two adjacent surfaces.

Fuel—Anything converted from one form to another with "release" of energy to perform useful work, as when coal is burned to produce heat to produce steam to run a turbine to produce electricity to light a lamp to help you read a book at night.

Fuel Cells—Battery-like, portable electric generators producing current from the reaction of hydrogen and oxygen.

Fusion—A joining, in particular, the combination of two atomic nuclei to yield one larger nucleus whose mass is less than the sum of the masses of the original nuclei. The lost mass appears as energy as in fission (see above). Because electrical charges within the nucleus make it very difficult to bring two nuclei close enough for fusion, the reaction requires extremely high temperatures and pressure (hence the synonym "thermonuclear reaction"). To generate useful energy, the reaction must be controlled; the hydrogen bomb represents an uncontrolled fusion reaction.

Geothermal—An energy source relying on natural steam rising from underground with enough force to drive turbogenerators.

Horsepower (hp)—A standard unit of measurement of power, equal to 33,000 foot-pounds of work per minute or the force required to do that much work. (A *foot-pound* is the force required to raise a one-pound object one foot straight up in the air, or its equivalent. In other words, one foot-pound of work may be done by lifting a one-pound object one foot, or a two-pound object one-half foot, or a half-pound object two feet.) A horsepower is more power than a real horse possesses over long periods, but less than it possesses in a short period of work. One horsepower equals 745.7 *watts*, where the watt is another measurement of power.

Hydropower—The energy of falling water harnessed to turn turbines to generate electricity.

Inertia—The resistance of an object to a change of state regarding its motion. Inertia is the condition reflected by the law of physics that an object at rest tends to stay at rest and an object in motion tends to stay in motion. It is a force which resists the transformation of an object's energy state from potential to kinetic or vice versa.

Kinetic Energy—The energy stored in a moving object. By moving, an object can perform work or move other objects to perform work. Kinetic energy of an object equals one-half the product of its mass and its velocity squared ($Ek = 1/2\ mv^2$).

Law of Conservation of Energy—The law of physics stating that the total amount of energy in a "system" (such as the Universe) is constant. Energy is neither created nor destroyed, but merely is constantly changing forms and states. Particular energy sources of fuels *do* disappear, however. This "law" has been revised in the light of findings that in nuclear reactions, matter is directly converted to energy. The reverse process is also true, and the law has been renamed the *Law of Conservation of Energy and Matter*.

Machine—Any system or object which, through any of a number of processes (burning, chemical reaction, atomic reactions) converts energy in one form (the fuel) into energy in another, more useful form (the product or output) plus some energy converted to a "waste" form.

Magnetohydrodynamics—A process of converting heat from combustion gases directly to electricity by passing gases through a magnetic field.

Oil Shale—Sedimentary rock which contains a substance yielding oil when heated.

Open Pit Mining—Strip mining.

Potential Energy—The energy stored in a non-moving object because of its position or inherent qualities. The force of gravity may act on any object as resisting forces are removed. Furthermore, some things, such as coal or wood, contain stored or potential energy which may be converted to heat energy through the process of burning.

Power—The rate at which work is done, expressed in units of work, such as foot-pounds, per unit of time. Energy is a capacity for doing something (work), whereas power is the rate at which the something is actually done.

Project Independence—Our government's goal of national self-sufficiency in energy.

Secondary Energy—Electricity may be thought of as secondary energy, for it requires conversion of a primary energy source such as coal, petroleum, or nuclear fission for its generation.

Short Ton—2000 lbs., the customary "ton" of coal, as distinguished from the "long ton," 2,240 lbs.

Solar—The sun as an energy source, harnessed by systems of collectors or solar cells over vast surfaces.

Tar Sands—Deposits containing an extractable petroleum substance.

Tidal—The tides as an energy source, converted by the same processes as hydropower.

Transformations of Energy—Changes in energy state from potential to kinetic or kinetic to potential. Energy transformations are brought about by three types of processes: mechanical (physical), chemical, or nuclear.

Transmission—Transportation of electrical energy from the point of generation to the point of use. Some energy loss is inevitable in transmission. Ten percent of the electricity actually generated is lost in transmission through power lines and cables.

Waste—That which is not useful to one's purposes. In certain energy conversion reactions, a resultant form of energy may perform no useful work for us, as for example, the sound generated by many machines. However, that sound may be useful energy in another process at another time, depending on our purposes, as when a whistling teakettle tells us the water is boiling.

Watt (w)—A common unit of measurement of power, especially electrical power. Named after James Watt, the famous Scottish engineer of the 18th century. One thousand watts, or one kilowatt (kw), is equal to 1.34 horsepower. Electrical power generation, or consumption, is commonly measured in kilowatt-hours (kw-hrs), where one kilowatt-hour is equal to the energy of one kilowatt of power acting for one hour.

Work—The conversion of energy which results in the movement of an object from one place to another in response to forces (mechanical, chemical, nuclear). The measurements for work have to do with heat generated (the calorie, Btu) or movement produced (the joule, electron volt, erg, foot-pound); any of these measurements may also be used to measure energy, the potential for work.

SUGGESTED TEACHING UNITS

Primary

Energy Conservation Teaching Resource Units

UNIT I: ENERGY AND HOW IT CAN HELP US

UNIT PURPOSE:

To help children understand what energy is and where it comes from.

ENABLING CONCEPTS:

A. Work: What it is

B. Energy for our bodies and where it comes from

C. *Energy all around us*

D. Energy for machines and where it comes from

Concept A. Work: What It Is

INSTRUCTIONAL OBJECTIVE:

To help children understand that *work* happens when something moves or changes in some way.

POINTS FOR EMPHASIS:

- Scientists use the word *work* differently than we do. They say that work happens when something moves or changes in some way.
- The word *work* is used many ways. Discuss hard work, work as a job, task, play which is work.

LEARNING ACTIVITIES:

The children may:

- Draw pictures of the kinds of work they do and the kinds of work (jobs) mothers and fathers do. Each picture should be analyzed for its scientific definition of *work*.
- Pantomime a type of work. The children try to guess what the work is.
- Write cooperative stories about "The Work I Do," "The Work Mothers Do," "The Work Fathers Do" and "Neighbors—People in the School and Community."
- Bring in or paint pictures which show work being done for a bulletin board display. The children tell about the work being done in their pictures.
- Select pictures from a collection of those on the bulletin board. (Some show work being done and some not.) Place the word *work* beneath each picture which shows something moving or changing in some way. Describe what could be done to move or change the items in the pictures where work is not happening.
- Make a scrapbook of original or commercial pictures of work being done. Children could write rebus and creative stories or captions for the pictures telling what is being moved or changed.
- Hear resource people, see films and go on field trips as learning experiences about work. The understandings that work occurs when something is moved or changed are emphasized.

- Illustrate the work animals do by observing, either firsthand or through visuals, birds building nests and feeding their young, wasps or bees building their homes, ants (use an ant farm) at work.

Concept B. Energy for Our Bodies and Where It Comes From

INSTRUCTIONAL OBJECTIVE:

To help children understand why our bodies need energy and where that energy comes from.

POINTS FOR EMPHASIS:

- Our bodies need energy in order to move or change in any way.
- *Energy* is being able to do work.
- The energy our bodies need comes from the food we eat.
- Our bodies work in the sense that parts of our bodies move and change.

LEARNING ACTIVITIES:

The children may:

- Do a short series of physical exercises: walk, hop, skip, jog and run a measured distance. Ask the children to determine which method of movement required the most work and to tell why.
- Find pictures of different types of food and try to classify the foods as primarily plant or primarily animal.
- Discuss the parts of plants which we eat: stems, roots, leaves, seeds.
- Discuss which animals give us beef, pork and other meats. What, in turn, are the foods for these animals?
- Make a cooperatively developed bulletin board entitled "Where We Get Our Energy."
- Identify the plant and animal components of such foods as bread, pizza, a milkshake, a hamburger.
- Discuss why it is important to eat three well-balanced meals per day and draw pictures of well-balanced meals.
- Discover and discuss the chain of life cycle.

Concept C. Energy All Around Us

INSTRUCTIONAL OBJECTIVE:

To expand the children's concept of energy from themselves to the world around them.

POINTS FOR EMPHASIS:

- Energy is all around us.
- We cannot see energy.

- People have energy.
- Animals have energy.
- The wind has energy.
- Water has energy.
- The sun has energy.
- *Energy* is being able to do work.
- Work happens when something moves or changes.

LEARNING ACTIVITIES:

Children can and do gather new information much as scientists do: by observing, asking people, visiting places, experimenting and reading. Children can be scientists in finding out about sources of energy.

They may:

- Draw pictures showing animals, the wind and water moving or changing in some way.
- Stand a safe distance in front of a fan to feel the force of the air. Face one fan against another (two feet apart). Turn on one. The other will be driven by the wind. (Energy transfer).
- Observe the energy of the wind through the use of pinwheels, a kite, bubbles, sailing leaf or paper boats, running against the wind, observing the wind bending tree branches and moving objects on the playground.
- Observe wind at work by making and watching a weather vane or windsock and by seeing the effect of a fan on a roller skate.
- Make an energy bulletin board—use pictures of animals, pinwheels, windmills, boats or water as headings. Children paint pictures of how these energy sources work.
- Make up riddles about sources of energy. Example: No one can see me. I blow and push. Who am I?
- Observe an animal to see the many different ways the animal moves or changes things (tadpoles, ant farm, fish, hamster, gerbil). Changes are most dramatic with amphibians or mealworms or chrysalis (cocoon).
- Put their hands under running water from a faucet to feel the force of the water. With a plastic coffee can top, make a water/wind wheel.
- Observe the movement of the water in a nearby body of water.
- Have a tug of war or bounce balls on the playground to observe the energy used by children.

Concept D. Energy for Machines and Where It Comes From

INSTRUCTIONAL OBJECTIVE:

To help children understand what machines are and how they change energy into useful work.

POINTS FOR EMPHASIS:

- Machines can do useful work.
- Machines are made by people.
- Machines change energy into useful work.
- Different machines change different kinds of energy into useful work.

LEARNING ACTIVITIES:

The children may:

- Experiment with a flat sled and a roller skate. Bakery twine is attached to sled and to skate. Books or other weights are put on each. Students pull sled and skate. Which is easier? Which can do most work? Load them both until string snaps. With which machine is more energy used?
- Draw pictures of at least five machines found at home.
- Each bring in an example of a machine and show how it moves or changes something.
- Name machines in a bulletin board display and tell what work each does.
- Make and demonstrate the use of an inclined plane, wheel, lever, and pulley. Bring to class toys which have one or more of these parts.
- Do demonstrations using simple machines and explain how they work.
- Identify and analyze items in classroom according to definition of *machine*. Is the light switch a machine? Pencil sharpener?
- Divide up into small "detective agencies" and have a contest to see which group can come up with the largest number of magazine pictures of different types of machines.
- Talk about why people and animals are like machines.

UNIT 2: ENERGY FOR TODAY AND TOMORROW

UNIT PURPOSE:

To help children learn about the major sources of energy which we use.

ENABLING CONCEPTS:

A. Today's energy sources and why we use them
B. The major energy sources used today are nonrenewable
C. New energy sources for the future

Concept A. Today's Energy Sources and Why We Use Them

INSTRUCTIONAL OBJECTIVE:

To make the children aware of the major energy sources used today and why we use these sources.

POINTS FOR EMPHASIS:

- The major energy sources we use today are oil, natural gas and coal.
- These sources of energy are stored in the earth.
- The major reasons we use oil, natural gas and coal as energy sources are that they are relatively easy to obtain and to transport.

LEARNING ACTIVITIES:

The children may:

- Examine samples of oil and coal.
- Make a display of examples of fossil fuels and label them.
- Examine a fossil, explore the meaning of the word *fossil*, and discuss the ways and the long time it takes fossil fuels to be formed.
- Make leaf prints in plaster of Paris or clay to develop the understanding of fossils.
- Build oil derricks with straws.
- Collect pictures of coal mines, oil derricks, gasoline pumps.
- Take field trip to a coal mine or oil field.
- Learn about static electricity by rubbing a comb with a woolen cloth.
- Watch demonstration by the teacher using a Bunsen burner to show the heat and light qualities of natural gas.
- Learn that coal and water energy are needed to make electricity.
- Learn how electricity works by inviting children from the middle school to demonstrate a buzzer, bell or light being activated by an electric switch.
- Categorize the machines they have in their homes by the energy source they use: oil, natural gas, coal or electricity.

- Read stories about coal miners and oil drillers.
- Discuss and write cooperative chart stories about how coal, oil, natural gas and electricity are transported.

Concept B. The Major Energy Sources Used Today Are Nonrenewable

INSTRUCTIONAL OBJECTIVE:

To make the children aware of the fact that the energy sources we use today will not last forever. When they grow up, there may not be these sources of energy.

POINTS FOR EMPHASIS:

- Our energy sources are being used up rapidly because more people are using more energy.
- The major energy sources we use today are nonrenewable.

LEARNING ACTIVITIES:

- The teacher brings to class a half dozen new boxes of crayons (balls, jumping ropes or other selected objects). The children count them. The teacher states these are all there are. Two children are invited to come to take crayon boxes. The teacher asks if there are enough left. Three more children are invited to take crayon boxes. The children are asked about what is happening to the supply and are reminded that there are no more. With the one box remaining, all of the children in the class are invited to come to get crayons. The teacher asks why all of the children can't have them. (*The children are led to realize that 1) there are no more; 2) that larger numbers of children needed the smaller amount of boxes; 3) that great care should be taken of the crayons which they have; and 4) that the crayons will need to be shared*).
- Learn the meaning of the word *nonrenewable* by tearing apart the leaves, stems and roots of a plant and trying to put the plant together in order that it will grow again. (Humpty Dumpty may be another example).
- The children recall the fossil fuels (coal, oil, natural gas) and the teacher compares them with the destroyed plant in that they are nonrenewable. They can be used up.
- Group discussions develop the understanding of what it would be like if we didn't have oil and natural gas or if we had very little coal. These ideas could be summarized in chart stories.

  Example: WITHOUT OIL

  — cars could not run

  — trucks could not carry food and clothing

  — some homes would be cold

  — people would be out of work

  — we could not go on vacations.
- Illustrate the chart *WITHOUT COAL—We Would Not Have*—The children draw pictures of the work and products supplied by coal which would not exist.
- Children pretend that there is no more electricity and describe all of the things they couldn't do or have if there were no electricity. They might tell and draw pictures of the things they would miss the most.

Concept C. New Energy Sources for the Future

INSTRUCTIONAL OBJECTIVE:

To make children aware that other energy sources may be available in the future but that time will be needed to develop them.

POINTS FOR EMPHASIS:

- Finding ways to make new energy sources work for us is going to be more difficult than it was to make oil, natural gas and coal work for us.
- Energy from the sun is called *solar energy*. Solar energy is one of the biggest sources of energy for the future. It is renewable because the sun is shining every day, even when the clouds cover it.
- Some other renewable sources are wind, water, the ocean tides, muscles, and using the things we throw away.

LEARNING ACTIVITIES:

The children may:

- Make a cooperative list of indications of the sun's heat. Examples—1. Comparing how it feels to sit in the sun and in the shade. 2. Noting the melting of snow. 3. Taking temperatures in sunny and shady rooms in the building. 4. Observing that the sun dries materials.
- Make "sun" mobiles with drawing attached of the work the sun does.
- Discuss and list what work the sun's energy can do.
- Make a simple windmill (four or five popsicle sticks with cardboard fan paddler glued to the stick). Drive the windmill with a fan. Discuss what work the wind may do for us that it is not being used to do today.
- Demonstrate a radiometer—put in sun, then in shade. Make it move with flashlight, burning match, flash bulb.
- Make shoebox gardens. Put some in the shade and others in the sun. Photograph or draw pictures of the various stages of plant growth to compare the two gardens and the sun's role in their growth.
- Make a sundial by using one child as the dial and the other children to draw the shadow. What does this tell us about the sun?
- Use a garden hose to move objects on the playground. Discuss the work water power may do for us today.
- View motion pictures showing the ocean tides. Discuss the force of the tides and how this energy may be used to perform work.
- Empty the wastebasket and discuss what materials in it could be used to make energy. Introduce the word *conversion* by talking about how these materials would have to be changed to be a source of energy. Make lists of what we have lots of at home and in the community which are thrown away but could be used to convert to energy. (Example: leaves, food cartons).
- Make *My Energy Books*. Children draw pictures and write sentence stories about how they can use their own energy to move or change things. Examples: Walking to school. Having vacation close to home.

UNIT 3: ENERGY CONSERVATION

UNIT PURPOSE:

To make the children aware of what they can do to conserve energy as well as the importance of everyone's helping to save energy.

ENABLING CONCEPTS:

A. The importance of conserving energy.

B. What we can do to conserve energy.

C. The importance of everyone's conserving energy.

Concept A. The Importance of Conserving Energy

INSTRUCTIONAL OBJECTIVE:

To make children aware of the importance of saving energy.

POINT FOR EMPHASIS:

- The understandings of limited supply and the need to share and to save are discussed by means of a ream of paper which must last the entire class for a certain period of time. The children are asked what they could do to make the paper last longer for the use of all of the children in the group. The understanding of the word *conservation* is the desired result. The conservation understanding is applied to energy use both at home and at school.

LEARNING ACTIVITIES:

The children may:

- Make up their own stories, telling why it is important to save energy. They might illustrate these stories on shelf-lining paper and present them in a simulated television set.
- Play the "Refrigerator Game." Ten items (eggs, milk, lettuce, and so forth) must be put into the refrigerator. Time the duration the refrigerator is open. Then prepare a dinner—opening refrigerator every time you need an item. Again time the seconds. By planning and organizing, one can cut the time the door is open, thereby saving energy. Transfer this to letting water run while brushing teeth and other routine activities.

Concept B. What We Can Do To Conserve Energy

INSTRUCTIONAL OBJECTIVE:

To make children aware of the ways in which they can help save energy.

POINTS FOR EMPHASIS:

- People can save energy by not wasting things. Every time something is wasted, the energy that went into producing it is wasted. The waste of food, pencils, paper, paper towels or anything else is a waste of energy.

- People can save energy by not misusing it. For example, many things in every house use energy. Some things that can be done to save energy at home and in school are
  - — lowering the heat in the winter
  - — wearing heavier clothing indoors in the winter
  - — keeping the doors and windows closed in cold weather to keep the warm air in
  - — turning off the radio or TV when they are not being used
  - — turning off lights that are not being used
  - — not using machines to do work that people could do just as well by themselves
  - — walking short distances rather than going in the car
  - — using public transportation
  - — riding in car pools
  - — reminding parents to drive at slower speeds
  - — having fun at home rather than asking to go distant places.

LEARNING ACTIVITIES:

The children may:

- Make a list of all the things they intend to do in order to save energy in school. These may be incorporated in a progress chart to be kept in a prominent place in the classroom. At the end of each day, the group's progress could be recorded on the chart. This progress may be reported to other groups over the public address system or in energy conservation assemblies.
- Make a growing list of how energy is saved each day by the class.
- Write individual or cooperative stories about how energy may be saved at home.
- Paint pictures of ways energy can be saved in homes.
- Report each day on one way in which energy was saved at home.
- Have a puppet show about how to save energy.
- Make individual energy conservation report cards which are marked by the child or family each week.

Concept C. The Importance of Everyone's Conserving Energy

INSTRUCTIONAL OBJECTIVE:

To make children aware of why it is so important for everyone to conserve energy.

POINT FOR EMPHASIS:

- It is important for everyone not to waste but to save energy in order that everyone may share in its use.

LEARNING ACTIVITIES:

The children may:

- Draw "what they think energy looks like." Have a group discussion in which children can talk about their pictures.
- Have a play about "how energy is used in my home."
- Draw or write about ways to conserve energy and discuss these ways.

- Help other people save energy by
  - — setting a good example and
  - — by letting other people know . . .
    - — how important it is to save energy and
    - — how they can go about saving energy.
- Paint poster pictures showing how to save energy and display these around the school (Do Not Waste Paper; Wear Warm Clothes; Turn Off Lights When You Leave the Room).
- Through creative dramatics, act out ways to save energy in the school.
- Write individual or cooperative stories about saving energy.
- Form an energy-saving club with the children conducting the meeting.
- Compete with another classroom on energy-saving games.
- Devise a plan to celebrate everybody's birthday *but* use only one box of birthday candles. (Generally there are 24 or 36 candles to a box.) Candles can be reused or only one used for each celebration. Get students to plan conservative measures so each celebration will be equally nice.
- Make *Save Energy* badges (safety pins and carton tops).
- Prepare a program and displays about energy and energy conservation to show parents at open house.

MY ENERGY CONSERVATION CHECKLIST

I. Some Ways to Save Energy in School

	Need No Improvement	Need a Little Improvement	Need Lots of Improvement
● Conserve paper.			
● Conserve crayons.			
● Conserve ____ (Fill in any additional items which the students tend to waste in school.)			
● Turn the lights off if they are not being used.			
● Other ____			

II. Some Ways to Save Energy at Home

● Conserve food.			
● Conserve water.			
● Conserve ____ (Fill in any additional items which the students tend to waste at home.)			
● Turn off lights when they are not being used.			
● Turn off the radio and TV when they are not in use.			
● Keep the doors and windows closed in cool or cold weather.			
● Wear warmer clothes in cold weather so the temperature does not have to be so high.			
● Other ____			

SUGGESTED TEACHING UNITS

Upper Elementary

Energy Conservation Teaching Resource Units

UNIT 1: WHY ENERGY IS IMPORTANT TO US

UNIT PURPOSE:

To help students become aware of what energy is and the vital role it plays in our lives.

ENABLING CONCEPTS:

A. Work: What it is

B. Energy's relationship to work

C. Using machines to change energy into useful work

Concept A. Work: What It Is

INSTRUCTIONAL OBJECTIVE:

To help students define *work* related to the concept of energy.

POINTS FOR EMPHASIS:

- The scientific definition of *work:* Scientists define *work* as a push or pull (a force) that causes an object or substance to move or change in some way. (Example: Writing with chalk, pencil or pen.)
- Some work is not controlled by man. Work can be done without man having anything to do with it. (Examples: Plants growing; sun drying clothes; waterfalls moving rocks.)
- Man does work. Some of this work is useful, some is wasteful and some is harmful. (Examples: Useful—construction; wasteful—leaving lights on when not in use; harmful—exploding bombs.)

LEARNING ACTIVITIES:

Students may:

- Write the definitions of the various types of work with an extended list of examples in energy notebooks.
- Each pantomime a type of *work* and have the other students try to guess what type of work it is.
- Play a game by having a student give a verb meaning some type of work and the others in the class make up a complete sentence using the verb. The verbs can be written on cards which are drawn for making up sentences about work.
- Have a "Tug of War" in which *no* work is done—that means no movement—on equilibrium of cancelling vector forces.
- Try to push the wall down, lift a book, push one hand against the other. When something moves, work was done in scientific sense.
- In small groups, prepare simple demonstrations of work and present them to the class. (Sample task: constructing a papier mache head using a balloon as a base.) The other students may record how many objects or substances were moved or changed in the course of the demonstration.

- Visit the playground and make a list of the different ways in which *play* is actually work.
- Construct lists of work done by man, animals, wind, water.
- Construct a bulletin board showing by classification types of work which are useful, wasteful or harmful.

Concept B. Energy's Relationship to Work

INSTRUCTIONAL OBJECTIVE:

To help students understand the relationship between work and energy.

POINTS FOR EMPHASIS:

- Everything has energy.
- Energy actually does work when it is an active state. A match has the ability to do work, but not until it is struck is it actually working.
- Energy is either at rest or active. The nail's energy is at rest until it is struck with a hammer. The energy of the hammer is inactive until it is used by a person. Energy is the ability to do work.
- Energy must be used to start or stop an object.

LEARNING ACTIVITIES:

Students may:

- Write the definition of *energy* in their energy notebooks.
- Collect pictures which show different types of work being performed and use the pictures to set up a bulletin board display. The display may have a caption such as . . . "It Takes Energy To Do Work."
- In small groups, design demonstrations showing energy being changed from the state of rest to an active state, and then describe the work that was performed as proof that the energy was actually changed into an active state. Demonstration example: Drive two identical nails into a two-by-four-inch pine block. Use a heavy hammer for the first. Use a tiny tack hammer for the second. Count number of blows. Let hammers fall—don't drive nail. Which was easiest? How much energy was used to accomplish same task?
- Give examples of the force of water, wind, chemical action, magnetism, electricity.
- Make dioramas showing some type of energy causing work to occur. (Example: The sun drying fish.)

Concept C. Using Machines to Change Energy Into Useful Work

INSTRUCTIONAL OBJECTIVE:

To help students understand how energy and work relate to machines.

POINTS FOR EMPHASIS:

- Machines are devices that change energy into useful work. Machines come in all sizes and all shapes. Some machines are very simple, and some are very complicated.
- The type of machine used to change energy into useful work depends upon the type of energy source being used (mechanical, chemical, nuclear).
- Machines increase speed, force and change direction.

LEARNING ACTIVITIES:

Students may

- Write the definition of *machine* in energy notebooks. Include illustrations of simple and complex machines.
- Study, construct and demonstrate the use of a lever, pulley, wheel and axle, inclined plane, wedge, windlass, and gears. Compare these to such items as scrapers, hammers, scissors, bicycles and doorknobs.
- Bring in actual samples of machines to demonstrate to the class.
- Make lists or sketches of the machines used in homes, schools, farming and a selected industry such as construction.
- Assume the role of detectives to find out where electricity comes from.
- Classify electrical appliances by the type of work they do (heat, light, make something move).
- Bring in pictures of machines and arrange them in a bulletin board display. The pictures may be classified by the type of energy source they convert into useful work (mechanical, chemical, nuclear).
- Collect catalogue pictures for a scrapbook and write what each machine pictured does.
- Make charts to classify machines by the type of energy they use—electricity, wind, water, animal, people.

UNIT 2: ENERGY SOURCES

UNIT PURPOSE:

To provide students with an awareness of the many energy sources available to us.

ENABLING CONCEPTS:

A. The energy sources available on our planet

B. The basic energy sources of today

C. Energy sources for the future

Concept A. The Energy Sources Available on Our Planet

INSTRUCTIONAL OBJECTIVE:

To provide students with an overall picture of the available energy sources, with emphasis upon renewable-nonrenewable dichotomy.

POINTS FOR EMPHASIS:

- Concept—The earth has three kinds of resources: inexhaustible, renewable, and nonrenewable.

Inexhaustible	Renewable	Nonrenewable
air	wood	gas
*sun		oil
water		coal

*The sun will continue to be our powerhouse.

- Solar, nuclear and geothermal sources of energy will power energy needs in the future.
- Finding new sources depends upon:

—seeking new materials

—minimizing waste

—learning how to use fuel more efficiently.

- Some energy sources are renewable. Solar energy, the earth's heat and tidal power will last as long as our planet and sun last. These are called *renewable* energy sources.
- Some of our earth's energy sources are limited. If we keep using these energy sources, eventually the supply will run out. These are called *exhaustible* or *nonrenewable* energy sources. The major exhaustible or nonrenewable energy sources on earth are fossil fuels (coal, oil and natural gas).

- The basic energy sources used in the United States today are ...
  - —oil (44%)
  - —natural gas (32.0%)
  - —coal (17.5%)
  - —hydropower (4%)
  - —nuclear power (1.0%)
  - —wood (1.4%)
- The major uses of energy in our society today are industrial, transportation, residential, and commercial. Much energy is lost in electricity generation.

LEARNING ACTIVITIES:

Students may:

- Prepare summaries in energy notebooks that itemize the major renewable energy sources and the major nonrenewable energy sources.
- Prepare committee reports on why the various types of fossil fuels are nonrenewable.
- Obtain samples of the major energy sources—coal, oil—for a display. Coke, charcoal might be included.
- Research the different forms of oil and natural gas and their uses.
- Research the different forms of coal and their uses.
- Make a large scale mural showing energy sources. (Mining, oil derricks, hydropower, geothermal.)
- Find out more about how nuclear reactors work and the types of fuel they use.
- Take a field trip to a local coal mine, oil field or nuclear reactor facility. (Students take photographs and slides.)
- Construct a bulletin board display showing the uses of energy by industrial, transportation, residential and commercial categories.
- Make an anemometer or wind gauge and demonstrate its use in determining the force of speed of wind and its direction.
- Demonstrate jet propulsion through the use of a balloon.
- Visit stream or river sites to discover and discuss the power of water which causes erosion and subsequent silt deposits which form deltas.
- Research and discuss the force of freezing water such as in the glacial plains.

Concept B. The Basic Energy Sources of Today

INSTRUCTIONAL OBJECTIVE:

To make students aware of the major energy sources utilized today and to emphasize the fact that these are nonrenewable.

POINTS FOR EMPHASIS:

- Oil, natural gas and coal are the major energy sources in use today. All are fossil fuels.
- Fossil fuels make up more than 90% of the energy sources used in the United States today. These fossil fuels all . . .
  - — are found primarily within the earth, which often means elaborate extraction techniques are required
  - — are storable and transportable
  - — are largely burned, performing useful work with heat energy
  - — have important nonfuel uses
  - — alter the landscape in their extraction
  - — release pollutants into the air when used.

LEARNING ACTIVITIES:

Students may:

- Make various types of graphs showing the relative percentages of use of both the major and minor energy sources in the United States today. This may become a part of their energy notebook.
- Bring to class examples of fossils and discuss how they were formed and how they might relate to fossil fuels.
- Make "fossils" such as plaster of Paris leaf prints.
- Visit a highway cut to observe layers of various deposits in order to discuss how fossils and fossil fuels were formed.
- Construct a chart showing the types of energy used by the family.
- Make maps showing the location of the major energy sources used in the United States today.
- Obtain maps of the location of both the major and minor energy sources in Ohio.
- Prepare reports on energy supply and demand.
- Prepare reports which tell the advantages and disadvantages of each of the fossil fuels.
- Make a time line showing the growth in the use of fossil fuels.
- Report on the major energy sources utilized in the community. Local resource people may discuss these energy sources.
- Construct a bulletin board classifying fossil fuels and their related uses.
- Have a panel discussion in which they debate the pros and cons of using fossil fuels.

Concept C. Energy Sources for the Future

INSTRUCTIONAL OBJECTIVE:

To make students aware of possible alternative energy sources for the future.

POINTS FOR EMPHASIS:

- Future energy sources should have high energy potential, be retrievable, easily obtainable, efficient for conversion, safe, healthful and environmentally noncontaminating.
- New energy sources are being studied for future use. Research is now being done to harness the following energy sources for the future:
    a. fossil fuel sources: oil shale, tar sands and coal gasification.
    b. natural or continuous sources: geothermal, solar, tidal and wind.
    c. other sources: hydrogen, fuel cells, magnets, hydrodynamics, burning of trash, nuclear fission (breeder reactors) and thermonuclear fusion.
- Several of these sources seem to have significant potential for future use.

LEARNING ACTIVITIES:

Students may:

- Study to learn the meaning of *coal gasification, geothermal, hydrodynamics, thermonuclear fusion*.
- Compare the relative benefits of energy sources on the basis of the characteristics of good energy sources. Small groups may each research one or two of the energy sources, recording data on each of the desirable characteristics for each energy source. With the group data compiled on the chalkboard, students may meet in committees to study the data and recommend which of the energy sources would be the better choices for future use.
- Prepare oral or written reports about the characteristics of energy sources. (High energy potential, obtainable, easily converted, safe and healthful, noncontaminating to the environment.)
- Research and report on current developments in explorations for new energy sources and in methods for harnessing these new energy sources to perform useful work.
- Collect magazine and newspaper articles dealing with energy sources for the future. The summary of these activities may be included in a class or individual energy notebook.
- Invite a resource person to discuss current developments in the search for energy sources for the future.
- Study the careers which are related to the development of energy sources and the uses of energy.
- Sort representative samples of school trash to determine potential utility of sorted trash as a fuel. (Cafeteria, classrooms, library, office, shop, gym.)
- Analyze domestic trash as a possible fuel source.
- Ask for permission to analyze commercial/industrial waste from a nearby plant for possible recycling.
- Write about some untapped source which could be converted into a new energy source. (Example: Throw-away trash.)

UNIT 3: THE ENERGY SITUATION AND WHAT WE CAN DO TO IMPROVE IT

UNIT PURPOSE:

To help students understand what the energy situation is and what must be done to improve the situation today and in the future.

ENABLING CONCEPTS:

A. How energy affects our lives

B. What we can learn from the energy crisis

C. The energy situation today and how we can improve it

D. What we can do to prepare for the future

Concept A. How Energy Affects Our Lives

INSTRUCTIONAL OBJECTIVE:

To make students aware of the tremendous part energy plays in our lives.

POINTS FOR EMPHASIS:

- Earliest man relied on his own energy (muscle power) to do the work required to meet his basic needs. He had to make everything without using nonhuman energy sources or machines of any kind.
- Today energy performs work through machines. There has been a rapid growth in the use of energy.

LEARNING ACTIVITIES:

Students may:

- List the energy sources available to earliest man as well as those not available. For example: fire, animals, moving water, wind, fossil fuels, electricity.
- Divide into small groups, each group to make three lists: one indicating ways in which energy is used in the school, one indicating ways in which energy is used in the home, and one indicating ways in which the students themselves use energy. The students should include the type of work, type of energy, and machine used for each way listed.
- Research the ways in which nonhuman energy sources affect

  —transportation capabilities

  —the roles and interaction of family members

  —food supply

  —location of homes

  —recreation

  Students may present their research findings in the form of a panel discussion, a bulletin board display, or written or oral reports.
- Plan a diary for a weekend during which little "outside" energy would be used—i.e., no bus, car transportation—no heating/air conditioning, TV, phone.

- Make and caption a page for their energy notebooks which consists of a collage of magazine pictures illustrating the many uses of energy in the United States today.
- Prepare reports on the causes of the rapid growth in the uses of energy.
- Write creative stories which tell about what life would be like without a certain kind of energy. (Example: electricity.)
- Write creative stories about using some new type of energy to produce materials.

Concept B. What We Can Learn From the Energy Crisis

INSTRUCTIONAL OBJECTIVE:

To provide students with a rationale for the need to conserve our fossil fuels.

POINTS FOR EMPHASIS:

- People have differing views on the nature of the energy crisis.
- Insufficient product and rapidly rising demand are the basic causes of the energy crisis. The energy shortages basically occurred when our steadily increasing demands for energy were not met because industries did not extract and refine fossil fuels (our major energy sources) fast enough. Legislation can encourage energy industries to increase the supply of fossil fuels to meet rising demands. But that is only a temporary solution. Our reserve supplies of fossil fuels will not last forever. They have been used as if they were inexhaustible.
- The energy crisis has given us a warning of what will eventually happen if we

  — continue to use fossil fuels at the present rate,

  — do not identify new and renewable energy sources, and

  — do not develop the technology to utilize these new sources.
- The careful conservation of fossil fuels will give us more time to develop technology to utilize new energy sources. It takes a long time to develop the technology to utilize new energy sources. We must start now in order to prepare for the future.

LEARNING ACTIVITIES:

Students may:

- Collect and report on newspaper articles dealing with evidences of local energy shortages.
- Write an editorial on "What's Good About the Energy Crisis."
- Interview a variety of community members to find what energy shortages they have experienced.
- Form an energy saving committee to warn others of energy misuse and waste.

Concept C. The Energy Shortage Today and What We Can Do About It

INSTRUCTIONAL OBJECTIVE:

To make students aware of what they can do to help ease the energy shortage today.

POINTS FOR EMPHASIS:

- Over the past 25 years there has been a tremendous increase in the demand for energy.
- To a large extent, the increased energy demand is caused by the population increase and its energy demands as well as industry's use of machines.
- Inefficient machines unnecessarily demand more energy. More machines are being built that do not use energy efficiently.
    - While providing the same amount of cooling, some air conditioners use up to two and one-half times as much electricity as others.
    - Frost-free refrigerators use 50 percent more electricity than standard models.
- Learn to look for energy efficiency. We can reduce the loss of energy by inefficient machines. It is important that everyone be concerned about buying machines that use energy efficiently. By using energy-efficient machines ...
    - more energy can be saved on a nationwide level, and
    - manufacturers will be encouraged to make products that are energy-efficient.
- List simple actions that can conserve energy. Our wasting of energy has added unnecessarily to the increase in the demand for energy. We tend to waste energy in many ways by wasting
    - products such as food, paper and pencils and the energy that went into making them.
    - using nonhuman energy to do things that we could do just as well by ourselves.
    - doing such things as leaving the lights on when we are not using them.
- There are things we can do to help conserve energy.

LEARNING ACTIVITIES:

Students may:

- Develop the Energy Conservation checklist, discussing each of the items in the checklist in order to answer any questions why a particular activity does in fact save energy.
- Develop and use inventories to determine how energy is wasted at home and in public places.
- Make up mathematical problems related to energy conservation. Sample problem: It costs about $367 a year for the average family to operate a medium-sized car. It costs about $235 a year for an average family to operate a compact car. How much money can the average family save by using a compact car?

  These can be exchanged by students.
- Examine a weekly grocery bag. Bring the unnecessary packaging to school. (Examples: polyshrink wrap on meat, cartons for toothpaste, aspirin, plastic bags for carrots, double wrap on frozen food.)
- Write and produce a puppet show to tell about energy conservation measures.
- Draw cartoons to illustrate current energy waste and methods of correcting it.
- Role-play what it would be like if we had no electricity, gasoline, or oil.
- Present a debate: Energy Needs versus Saving the Environment.

Concept D. What We Can Do to Prepare for the Future

INSTRUCTIONAL OBJECTIVE:

To make students aware of what needs to be done and how they can help to insure the availability of energy sources in the future.

POINTS FOR EMPHASIS:

- We must prepare now to insure adequate usable energy sources for the future. We have seen the need for conserving energy to help ease the energy shortage today, but what about the future? Regardless of how well we conserve our nonrenewable energy sources, eventually they will run out. We need to start now to prepare for the future. We need to research and develop renewable energy sources. This is a big job and will take time.
- It is important to conserve the energy sources currently in use to give us more time to prepare for the future. If we conserve our present energy sources, we can increase the time that we have to develop new energy sources. In order to conserve a significant amount of energy, EVERYONE has to help.
- Everyone can help to insure the availability of energy sources in the future by
  - conserving today's energy sources, and
  - supporting research to develop new energy sources for the future.

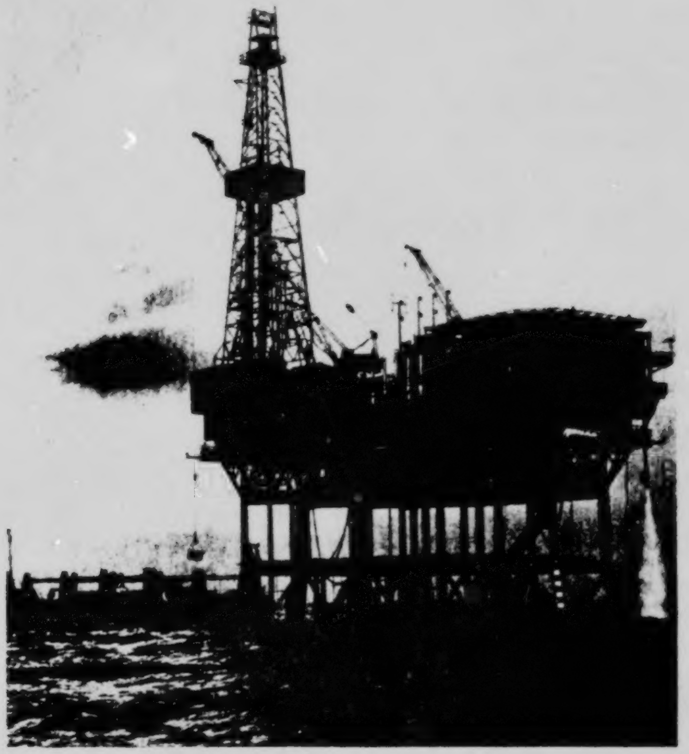
LEARNING ACTIVITIES:

Students may:

- Research and report on careers directly related to energy conservation.
- Read periodicals to learn about legislation which is being proposed or adopted regarding the energy situation.
- Design posters or write newspaper editorials to convince people of the importance of planning ahead to insure adequate, usable energy sources for the future.
- Hold an energy education fair where student-prepared models and charts are displayed.
- List all the ways in which they personally can save energy both at home and in school.
- Organize an energy club to be a "Clearinghouse" for recycling information--i.e., newspapers, magazines, aluminum cans, glass, Christmas cards, egg cartons, and other throwaways. Challenge students to find another (perhaps creative) use for our disposable trash items.
- Hold class and student council meetings to propose and adopt through student vote ways that energy may be conserved in the school.
- Have a media show made up of slides of energy sources and types of work, taken and described by students.
- Prepare and publish a school newspaper about energy and energy conservation.
- Maintain a collection of library books and periodicals to be researched as a basis for oral and written reports.

SUGGESTED TEACHING UNITS

Junior High and Middle School



Energy Conservation Teaching Resource Units

UNIT 1: ENERGY—WHAT IT IS AND HOW IT RELATES TO WORK

UNIT PURPOSE:

To help students become aware of what energy is, how it affects today's life style and how it relates to work.

ENABLING CONCEPTS:

A. What is work?

B. The importance of energy

C. How machines help change energy into useful work

D. Energy's relationship to work

Concept A. What Is Work?

INSTRUCTIONAL OBJECTIVE:

To provide the students with a definition of *work* which will help them understand the concept of energy.

POINTS FOR EMPHASIS:

- There are many different ways to define *work*. When we talk about *work*, we are often talking about things we have to do personally. Scientists define *work* as a push or pull (called a force) which causes an object or substance to move or change in some way.
- When anything moves or changes in some way, work has been done. Work is done in nature without man's intervention. Some of this work is helpful to man; some is harmful; and some has no effect at all.
- Man performs work, sometimes alone, and sometimes with the aid of a machine. Some of the work performed by man is useful to man, some is wasteful and some is harmful.
- Useful work is the work that man wants done.

LEARNING ACTIVITIES:

Students may:

- Write the following definitions in energy notebooks and develop the meaning in several expanded paragraphs.

  WORK IS A PUSH OR PULL WHICH CAUSES AN OBJECT
  OR SUBSTANCE TO MOVE OR CHANGE IN SOME WAY.
  USEFUL WORK IS WORK THAT MAN WANTS DONE.
- Prepare simple demonstrations of *work* and present them to the class.
- Construct a bulletin board display of the various types of work: useful, wasteful, harmful.
- Discuss the types of work our bodies do in the normal life processes (breathing, eating) and how these relate to the scientific definitions of *work*.

- Discuss the types of work we do each day from the time we awaken until the time we retire. Which of these activities do we consciously think of as work and which do we classify in some other way?
- Research and orally report on work that happens in nature, over which man has no control. Examples: The wind transporting seeds, tornado, hurricane, tidal wave, glaciers.

Concept B. The Importance of Energy

INSTRUCTIONAL OBJECTIVE:

To make the students aware of the effect of energy on today's life style.

POINTS FOR EMPHASIS:

- Earliest man relied on his own energy (muscle power) to do the work needed to meet his basic needs. Nearly everything was made without nonhuman energy sources or machines.
- Civilization evolved as man continuously searched to find nonhuman sources of energy to perform useful work. By utilizing nonhuman energy sources, man has been able to accomplish work more efficiently.
- By utilizing nonhuman energy sources, man has been able to do things that could not have been done with muscle power alone.
- Technology represents man's efforts to find new, more efficient ways of using nonhuman energy sources to perform useful work.

LEARNING ACTIVITIES:

Students may:

- Be challenged to "brainstorm" an industry that would not have a high energy requirement (only human and animal sources—no electricity).
- Prepare a research paper about the beginning of the uses of different sources of energy. Include maps showing where energy sources were first used and a timeline to show when.
- Prepare a talking mural which would illustrate and discuss the discovery, development and use of various energy sources from the time of the caveman to the present. (Pictures and tape narrative are student prepared.)
- Write a paper on how using sources of energy has affected the evolution of our life style.
- Take a field trip to the local historical museum to view actual examples of the evolution of modern technology.
- Write a paper about what life would be like without the use of nonhuman energy sources.
- Write an original science fiction story about the uses of new sources of energy.
- List sources of potential energy and have students discuss how they may become kinetic.

- On a map, color code those areas of the United States that might be able to use tidal energy and wind energy.
- Compare heat energy content of 10 grams of coal, charcoal, wood, gas, and alcohol. See how much water can be boiled with each sample. (Different woods have different calorie potentials.)

Concept C. How Machines Help Change Energy into Useful Work

INTRUCTIONAL OBJECTIVE:

To help the students understand how machines help us change energy into useful work.

POINTS FOR EMPHASIS:

- A machine is a device that changes energy into useful work.
- Machines can change energy into useful work through mechanical, chemical and atomic means.
- Mechanical energy is released by an object in motion.
- Chemical energy is released by the reacting of two or more elements.
- Nuclear energy can be released through either of two processes: through fusion, the joining of atomic nuclei, and through fission, the splitting of an atomic nucleus.
- Machines transfer a force (push or pull) from one place to another.
- All of a machine may be involved (as a broom) or only parts of the machine (as a bicycle).
- Machines may change the direction of a force (as a pulley) or increase the amount of force (as pliers).
- Machines may increase the distance through which a force acts (as a broom or a bicycle).
- The work (output) of a machine equals the energy (input) put into it.
- Machines, however, conserve the amount of human energy expended.
- For operating machines, we need energy sources that (1) can be converted into kinetic energy in the machines, (2) are abundant, and (3) are closely available or can be transported easily.
- Sometimes a series of machines may be needed to convert energy into useful work.

LEARNING ACTIVITIES:

Students may:

- Bring in examples of machines and demonstrate their use.
- Discuss how the following items are considered machines: knife, fork, spoon, scissors, can opener, egg beater, meat grinder, doorknob, broom, shovel, rake, hoe, hammer, nail, screw, screwdriver, wrench, saw, hatchet, chisel, pliers, tweezers, crowbar, lawn mower, and wheelbarrow. What are some other simple machines we have around the home?

- Develop a timeline showing when commonly known machines were invented or came into active use. Examples: car, airplane, tractor, plow, sewing machine, washer, bicycle.
- Write about particular machines which changed civilization. Examples: printing press, telegraph, electric light, internal combustion engine.
- Trace the evolution of a particular type of machine.
- Research and write reports on the nature and use of nuclear, solar or geothermal energy.
- Trace the basic energy conversion processes within a complex machine such as an automobile engine or telephone.
- Construct a bulletin board display classifying pictures of machines by the type of energy used (chemical, solar, wind, water, nuclear).

Concept D. Energy's Relationship to Work

INSTRUCTIONAL OBJECTIVE:

To help the students understand the relationship between work and energy.

POINTS FOR EMPHASIS:

- Energy is the ability to do work.
- In some way, everything has energy (the ability to do work) in the scientific sense of either moving or changing in some way.
- At a given moment, energy is either at rest or active.
- Energy at rest is called *potential energy*.
- Energy in action is called *kinetic energy*.

LEARNING ACTIVITIES:

Students may:

- Write examples and draw illustrations of *energy, potential energy,* and *kinetic energy*.
- Each design a simple demonstration of how potential energy can be changed to kinetic energy and present the demonstration along with an oral report.
- Research and present an oral report and demonstration on the uses of wind as an energy source. (Possible source: NASA windmill near Sandusky.)
- Research and present an oral report and demonstration on the uses of water as an energy source. Include in the report a discussion of the water wheel and water turbine.
- Research and report on how steam, exploding gas and atomic energy are used to run machines.
- Research and report on how electricity makes machines operate.
- Calculate miles per gallon for all the parents' cars for one week. Summarize and generalize on efficiency of generic types (compacts, subcompacts, full size, station wagons). Compare with EPA findings.
- Determine energy requirement to run all machines in shop, school office, and maintenance department. (Name plate on each machine has data.)

UNIT 2: ENERGY SOURCES

UNIT PURPOSE:

To make students aware of the scope of energy sources available on this planet and of the relative advantages and disadvantages of utilizing each of these energy sources.

ENABLING CONCEPTS:

A. Characteristics of "good" energy sources

B. The energy sources used today

C. Energy sources of the future

Concept A. Characteristics of "Good" Energy Sources

INSTRUCTIONAL OBJECTIVE:

To provide the students with a set of criteria for comparing the relative desirability of different energy sources.

POINTS FOR EMPHASIS:

- To convert energy into useful work, we must begin with a "useful" energy source. Although everything has energy, not everything can be changed into useful work.
- The characteristics of "good" energy sources:
  - High energy potential
  - Abundant available supply
  - Relatively easy to obtain
  - Relatively easy to convert the energy source into useful work
  - Extraction and use of the energy source should not have negative environmental effects or in any other way pose a health threat.
- There is no perfect energy source. In order to compare the relative desirability of energy sources, one must consider their strengths and weaknesses in each of the five characteristics.

LEARNING ACTIVITIES:

Students may:

- Use the five characteristics to compare various energy sources.
- Write reports describing the factors which affect the available supplies of a particular energy source at a given time.
- Write reports on how modern technology has affected conversion efficiency and the environment.
- Research and discuss the contributions of various nations to energy technology.
- Examine and burn small quantity of soft and hard coal; hard and soft wood; charcoal and coke. What differences are noted?

Concept B. The Energy Sources Used Today

INSTRUCTIONAL OBJECTIVE:

To make the students aware of the major energy sources utilized today and to emphasize the fact that these are nonrenewable.

POINTS FOR EMPHASIS:

- The available energy sources fall into two basic categories: renewable and nonrenewable.
- The major renewable energy sources are direct solar radiation, the heat of the earth, tidal energy, and wind.
- The major nonrenewable energy sources are the fossil fuels (coal, oil, and natural gas) and fissionable elements (nuclear power).
- In the mid 1970's, our major energy sources are oil (44% of total national energy consumption), natural gas (32%) and coal (17.5%). Our minor energy sources are hydropower (4%), nuclear power (1%), and wood (1.4%).
- Historically, man has relied to a great extent on fossil fuels.
- Today's technology is almost totally geared to using nonrenewable fuels (oil, natural gas, and coal). The following is a breakdown of the U.S. use of fossil fuels.
  - Industrial: 32.1%
  - Transportation: 25.1% (Public: 10.8%; Autos: 14.3%)
  - Loss in Electricity Generation: 17.6%
  - Commercial: 12.6%
  - Residential: 12.6%

LEARNING ACTIVITIES:

Students may:

- Research and make maps showing the location of supplies of major energy sources used in the United States today. Use this information to study world trade, alliances, and conflict among nations.
- Analyze the problems of allocation of energy supplies in the United States and among the nations of the world and discuss findings in class.
- Discuss the pros and cons of government-proposed policies for allocation of energy supplies. Relate this to self-interest as compared to cooperation on an individual, community, national and international basis.
- Research and make maps of the location of both the major and minor energy sources in Ohio.
- Write a paper drawing inferences from the fact that more than 90% of the energy sources we have the ability to utilize today are nonrenewable.
- Study the waste factors in the conversion and use of present day fuels and present findings to the class.
- Contact a utility (for example, Columbus and Southern Ohio Electric) for copies of their annual report—or find out how much coal/oil/gas the company used to produce their total kilowatt output. What are the costs of fuel? Cost of electricity? What are plans for future generating stations, fuel supplies?

- Divide into groups in order to research each energy source used today in terms of the five criteria of "good" energy sources and report their findings to the class.
- Picture a house and estimate the amounts of fossil fuel used by a family of four during a year.
- List under each heading examples of the uses of fossil fuel energy:
  - — Transportation
  - — Residential
  - — Commercial
  - — Industrial
- Using the same headings of Transportation, Residential, Commercial and Industrial, list problems caused by fossil fuel energy shortages.

Concept C. Energy Sources for the Future

INSTRUCTIONAL OBJECTIVE:

To acquaint the students with possible alternative energy sources for the future.

POINTS FOR EMPHASIS:

- Research is now being done to harness the following potential energy sources:

  Fossil fuel sources—oil shale, tar sands, and coal gasification

  Natural or continuous sources—geothermal, solar radiation, tidal power and wind

  Other sources—hydrogen, fuel cells, magnets, hydrodynamics, burning of trash, nuclear fission (breeder reactors) and thermonuclear fusion.

LEARNING ACTIVITIES:

Students may:

- Research and report on current developments and explorations for new energy sources and on methods for harnessing these new energy sources.
- Research and discuss the methods which are being proposed to improve use of fossil fuels.
- Invite a resource person to discuss current research developments in the search for energy sources for the future.
- Describe what they think would be an ideal energy source for the future.
- Think of untapped sources which may be used to perform work.
- Study careers related to energy research, development and use. Invite speakers to the class or to an assembly to discuss energy-related careers.
- Maintain an energy current events scrapbook or bulletin board of ongoing developments written up in newspapers and periodicals.
- Have an energy education fair displaying models and charts that they have prepared to show the various types of fuel and the advantages and disadvantages of their use.

UNIT 3: THE ENERGY SITUATION TODAY

UNIT PURPOSE:

To make students aware of the major factors influencing the energy situation today.

ENABLING CONCEPTS:

A. How energy is used in the United States today

B. The domestic supply of fossil fuels in the United States today

C. Factors affecting the availability of fossil fuels in the United States today

D. What we can learn from the energy crisis

Concept A. How Energy Is Used in the United States Today

INSTRUCTIONAL OBJECTIVE:

To make the students aware of the major uses of energy in our country today and of the far-reaching effects an energy shortage has on each of these areas of use.

POINT FOR EMPHASIS:

- Energy is so much a part of our lives that, if we have a problem with our energy supply, most aspects of our lives are affected.

LEARNING ACTIVITIES:

Students may:

- List the types of problems a serious energy shortage causes in the transportation, residential, commercial and industrial areas of energy use.
- Prepare a report that deals with the major uses of energy today. Include use on a home, school, community, national and international basis.
- Prepare posters depicting the many different uses of energy in our society today.
- Research the process through which electricity is generated and suggest what might be done to generate electricity without wasting our supplies of fossil fuels.
- Report on the major energy sources utilized in their community. Local resource people might be invited in to elaborate further on the energy sources utilized locally.
- Learn to read electric and gas meters to determine home energy use and become familiar with measurement terms such as *kilowatt hour*.

Concept B. The Domestic Supply of Fossil Fuels in the United States Today

INSTRUCTIONAL OBJECTIVE:

To make the students aware that, although our supply of fossil fuels will not last forever, current fuel shortages are a result of shortages in the availability of fossil fuels as well as shortages in our reserve supplies of fossil fuels.

POINTS FOR EMPHASIS:

- All the major sources of energy are fossil fuels.

  Coal

  If all of our energy came from coal, all of the coal resources in the United States available today would last us approximately 125 years.

  It is estimated that there are currently undiscovered resources of coal in the United States which could last us up to 1300 years.

  Petroleum

  If all of our energy came from petroleum, all of the petroleum resources in the United States available today would last us approximately 5 years.

  It is estimated that there are currently undiscovered resources of petroleum in the United States which would last us up to 280 years.

  The United States is dependent for this energy source upon other countries.

  Natural gas

  If all of our energy came from natural gas, all of the natural gas resources available in the United States today would last us approximately 5 years.

  It is estimated that there are currently undiscovered resources of natural gas in the United States which could last up to 110 years.

  Oil shale

  If all of our energy came from oil shale, it is estimated that there are currently enough undiscovered resources of oil shale to last us 2500 years.

- The potential or untapped reserve supply of domestic fossil fuels in the United States can only be estimated. However large, it is not unlimited.
- The availability of domestic energy sources has not increased as rapidly as the demand.

LEARNING ACTIVITIES:

Students may:

- Research and write reports on the following topics:

  The energy reserves available in Ohio

  How long these reserve supplies will last

  What can be done to extract and utilize the energy reserves in Ohio more effectively

  The probable causes of the energy shortage

  The relationship of supply and demand

  The effect of importing on the economy

- Conduct a simulated Congressional hearing on the granting of rights to drill in the Atlantic between the 3-mile and 12-mile limit. Is it federal or state domain? Represent governor of New Jersey, senator from Ohio, EPA official, oil company representative, and others immediately affected.
- Study and discuss proposed legislative measures relating to energy, such as rationing, progressive tax on horsepower.

Concept C. Factors Affecting the Availability of Fossil Fuels in the United States Today

INSTRUCTIONAL OBJECTIVE:

To make the students aware of the factors affecting the availability of fossil fuels in the United States today and of possible solutions to the problem of availability.

POINTS FOR EMPHASIS:

- Although our reserve supplies of domestic fossil fuels are not depleted, there are shortages.
- The key factors affecting the availability of supplies of fossil fuels in the United States today are nationwide economic policies, environmental legislation, and lack of funding for research and development of untapped and new sources of energy, including waste conversion.
- NATIONWIDE ECONOMIC POLICIES

  Nationwide economic policies have kept the price of energy low in this country, much lower than in other nations. The fact that energy prices in this country are lower than in other countries has had the most damaging effect on the availability of domestic petroleum and natural gas.

  Low nationwide price policies have encouraged "American" oil industries to sell their products to foreign countries in order to get higher prices, and to increase foreign energy supplies through exploration and expanding refinery capacities in foreign countries.

  Low price policies have discouraged "American" industries from exploring for new domestic resources and expanding refinery capacities in the United States.
- ENVIRONMENTAL LEGISLATION

  Environmental legislation has affected the current availability of domestic energy supplies.

  > Legislation to halt extraction of oil off the coast of southern California put an end to our utilizing one of the major untapped oil deposits in the United States.
  >
  > Legislation for a time blocked the construction of the Alaskan pipeline to transport the large Alaskan oil reserves.
  >
  > Many groups of concerned citizens oppose construction of nuclear plants for reasons of safety. Many citizens also oppose coal mining practices that scar the landscape.
- NONFUEL USES OF FOSSIL FUELS

  Another factor that has affected our available supply of fossil fuels is the tremendous increase in the demand for using the potential fuels for nonfuel purposes.

  For example, gas is used in the manufacture of synthetic rubber, oil and water-based paint, dishes, D.D.T., indigo dyes, paper coatings, plastics, explosives, carbonated beverages, anti-freeze, aerosols, films and vinegars.

LEARNING ACTIVITIES:

Students may

- Interview a government representative on

  The reasons behind governmental controls on fossil fuel prices

  What new legislation is being proposed to improve the availability of domestic fossil fuels.

- Conduct a panel discussion in which half take the side of the environmentalists and half take the side of individuals who are primarily concerned with the prospect of severe energy shortages in the near future. They may suggest types of governmental policies which would encourage the development of domestic energy supplies while still maintaining high environmental standards.
- Make a bulletin board display of the types of products affected by the shortage of each of the three fossil fuels.
- Devote an entire issue of the school newspaper to the subject of energy: editorial, news articles, cartoons, features, interviews.
- Discuss the relative importance of using nonrenewable fossil fuels for nonfuel purposes.

Concept D. What We Can Learn from the Energy Crisis

INSTRUCTIONAL OBJECTIVE:

To make the students aware of what the energy crisis is all about and what we can learn from it.

POINTS FOR EMPHASIS:

- The energy shortages facing our country today have occurred because of the following circumstances:

  Population increases

  The constantly increasing demand for more and more oil within the United States (travel, greater production, more appliances)

  Domestic supplies of oil which were too low to meet this increasing demand

  The need to import oil and natural gas to meet the increasing domestic demand

- The Middle East oil embargo hastened the impact of our growing energy problem.
- The energy crisis has clearly emphasized three needs which are critical to our nation's survival:

  1. The necessity for our nation to become self-sufficient in supplying our energy needs.
  2. The necessity of our finding new and renewable energy sources and developing feasible techniques for their utilization so that we are prepared for the time when we have exhausted all of our supplies of fossil fuels.
  3. The need to conserve our fossil fuel supplies as long as possible so that we have more time to research and perfect techniques of utilizing new energy sources.

- In effect, we can view this crisis as a blessing in disguise, because it has focused public attention on the total energy situation. This concern may motivate Americans to prepare for future shortages. The effects of the shortages and crisis have jolted us into an awareness of what will happen if we ignore the situation.

LEARNING ACTIVITIES:

Students may:

- Write a newspaper article on "How the Energy Crisis Has Affected My Family."
- Interview different members of their community to find out how the energy crisis affected them.
- Write an editorial on "What's Good About the Energy Shortage." (Awareness of the problem and time to work toward its solution.)
- Collect and report on newspaper articles dealing with evidences of local energy shortages.
- Prepare graphs showing supply and demand.
- Discuss the effects of importing on the economy in the United States.
- Discuss the effects of the concentration of the world's energy reserves in terms of relationships among nations.
- Invite a representative of an environmental group, government agency and local power company to speak about community energy problems. Thoughtful questions should be listed ahead of time.
- Visit an oil refinery, electric generating plant, coal mine or other similar installation. Write reports or conduct class discussion on the findings.
- Prepare and distribute a field trip sourcebook in which are listed energy-related industries which can be visited, contact persons, times to visit, appropriate age groups, and what may be seen.

UNIT 4: WHAT WE CAN DO TO EASE THE ENERGY SHORTAGE TODAY AND PREPARE FOR THE FUTURE

UNIT PURPOSE:

To make students aware of what needs to be done and how they can help ease the energy situation of today and of the future.

ENABLING CONCEPTS:

A. What we can do to ease the energy shortage today

B. What we can do to prepare for the future

Concept A. What We Can Do To Ease the Energy Shortage Today

INSTRUCTIONAL OBJECTIVE:

To make the students aware of how they can ease the energy shortage today through decreasing their demand for energy.

POINTS FOR EMPHASIS:

- It is important to conserve our fossil fuels for two major reasons:

  To give us more time to identify new energy sources and to develop the technology required to convert these new energy sources into useful work, and

  To save as much of our fossil fuel supply as possible for nonfuel purposes.

- Individuals can do many things to conserve energy.
- One factor which contributes to the tremendous demand for energy is that many machines today are not designed to use energy efficiently. For example, while providing the same amount of cooling, some air conditioners use up to two and one-half times as much electricity as others. Frost-free refrigerators use 50 percent more electricity than standard models.
- It is important to compare efficiency of energy use in different products before deciding which brand to buy. This practice will encourage manufacturers to develop products that use energy efficiently.
- The tendency of Americans to waste energy is another very important factor in the tremendous demand for energy. We tend to use nonhuman energy to do things that we could do just as well ourselves or to do things that don't really need to be done. Our consumption also is marked by obvious neglect, such as when we leave lights on in unoccupied rooms or leave the TV on when no one is watching.

LEARNING ACTIVITIES:

Students may:

- Research and prepare reports on the relative efficiency of different brands of the same product. Each student (or small group of students) may select a different product and compile a composite report of the findings for distribution to other groups and to parents. (A student version of *Consumer Report*.)

- Simulate a discussion by a family that has learned their winter heat allocation will be decreased by 20 percent. The "family" should list ways of dealing with the problem.
- Set up personal energy conservation goals. Make a checklist or scorecard.
- Compile energy-saving checklists for home and school use.
- List every energy-using item within the home and ask each family member to rank them in order of importance.
- Have a contest to see whose family can reduce energy use the most in one week. Review the reading of electric and gas meters, record the readings for a one-week base period, and compare readings after a one-week reduction effort.
- Design brochures to inform the public about what they can do to ease energy demand.
- Compare automobile advertisements of today with those of 5 or 10 years ago. How are they the same? How are they different?
- Compare utility company advertising of today with examples from 5 and 10 years ago.
- Prepare programs on energy conservation to be given in assemblies, over the public address system or to community organizations.
- List ways that energy is wasted along with ways to prevent the waste.
- Conduct a survey to find information such as how many cars pass a designated point with a driver but no passengers.
- Conduct a survey to determine how community businesses and industries are cutting back on energy use—hospitals, department stores, motels, and others.

Concept B. What We Can Do To Prepare for the Future

INSTRUCTIONAL OBJECTIVE:

To make students aware of what needs to be done and how they can help to insure the availability of energy in the future.

POINTS FOR EMPHASIS:

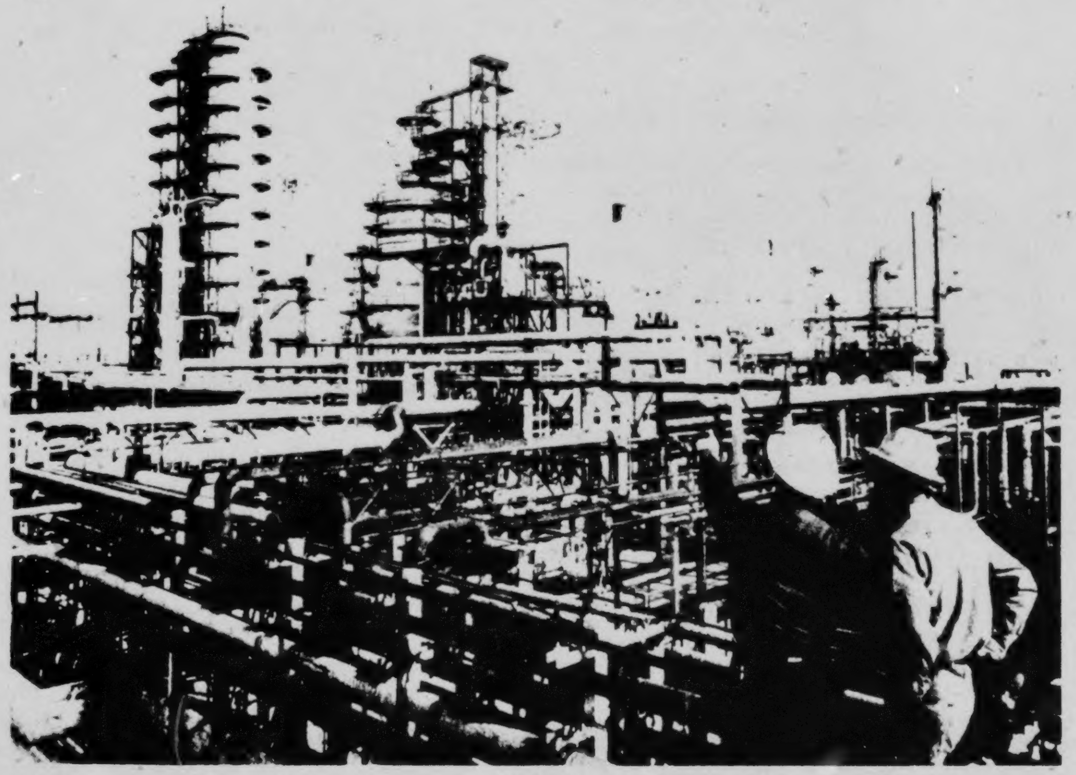
- We have seen the need for conserving energy to help ease the energy shortage today, but what about the future? Regardless of how well we conserve our nonrenewable energy sources, eventually they will run out.
- We need to start now to prepare for the future by researching and developing renewable energy sources.
- Developing new, renewable energy sources sufficient to meet our national needs is a phenomenal task that will require a great deal of time. Conserving energy today will give us more time, but a wholehearted national commitment to energy conservation is essential.

LEARNING ACTIVITIES:

Students may:

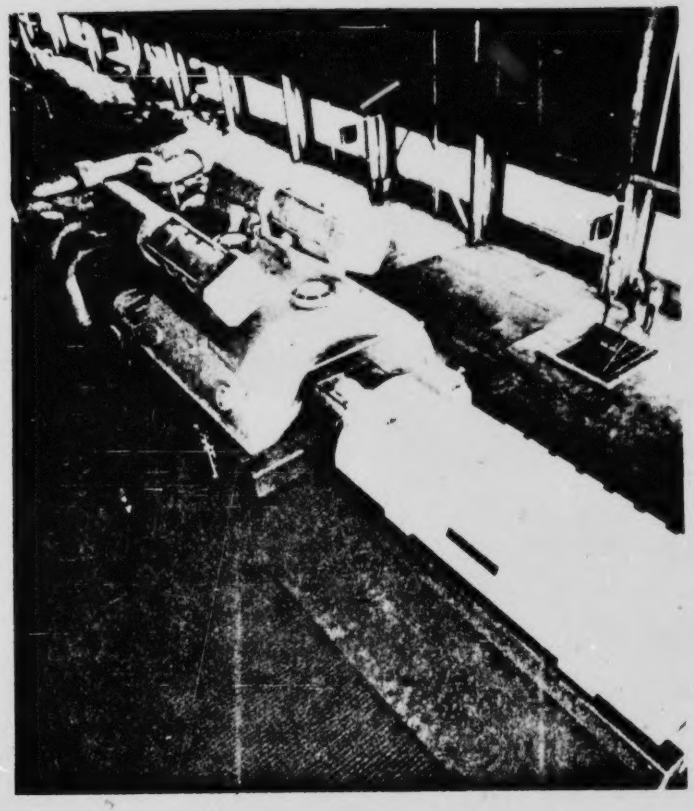
- Design posters to encourage others to conserve energy.

- Have a panel discussion in which half of the panel represents business men whose businesses are largely dependent upon the use of fossil fuels and the other half represents legislators concerned about insuring an adequate supply of usable energy for the future. The panel may discuss whether or not a bill should be passed to provide substantial financial support for research in the area of harnessing new energy sources.
- Devote an entire issue of the school newspaper to how all individuals can help encourage others to conserve energy.
- Contribute articles on conservation practices to the local newspaper.
- Write to congressmen to find out what legislation has been passed or is being proposed to help insure adequate, available, usable energy sources for the future.
- Prepare and give a program on energy conservation as a part of the public service programming of local radio or television stations.
- Hold class and student council meetings to propose and adopt, through student vote, energy conservation measures for the school.
- Elect an energy conservation committee for the school.
- Develop value objectives in forming an individual energy conservation ethic.



SUGGESTED TEACHING UNITS

Senior High



Energy Conservation Teaching Resource Units

UNIT 1: ENERGY—WHAT IT IS AND HOW IT AFFECTS OUR LIVES

UNIT PURPOSE:

To help students become aware of what energy is and of the tremendous influence it has on our lives.

ENABLING CONCEPTS:

A. Energy's relationship to work

B. How machines help change energy into useful work

C. The importance of energy

Concept A. Energy's Relationship to Work

INSTRUCTIONAL OBJECTIVE:

To help clarify students' understanding of energy as the ability to do work.

POINTS FOR EMPHASIS:

- *Work* is a push or pull which causes an object or substance to move or change in some way.
- *Energy* is the ability to do work. Everything has energy or the ability to do work in the scientific sense of either moving or changing in some way.
- Energy is classified in one way as potential and kinetic. *Potential energy can* perform work but is *not* performing work at the moment. *Kinetic energy* is energy that is actively performing work.
- Work happens in nature without man's control or direction.
- Man, sometimes alone, and sometimes with the aid of a machine, performs work. Some of the work performed by man is harmful to man, some is useful to man, and much is wasteful.

LEARNING ACTIVITIES:

Students may:

- Give verbal examples of how potential energy is changed into kinetic energy that performs useful work.
- Demonstrate through simple experiments how potential energy can be changed into kinetic energy in order to perform useful work. Striking a match is a simple example.
- Research and report on one of the ways work happens in nature without man's control or direction, such as the hydrologic cycle.
- Research and discuss how man has intervened, for good or bad, in some natural work cycles.

Concept B. How Machines Help Change Energy into Useful Work

INSTRUCTIONAL OBJECTIVE:

To help students understand how machines help change energy into useful work.

POINTS FOR EMPHASIS:

- A *machine* is a device that changes energy into useful work. Machines can change energy into useful work through mechanical, chemical, and atomic means. Mechanical energy is released by an object in motion. Chemical energy is energy released by the reacting of two or more elements. Nuclear energy is released through either of two processes:

  — through fusion, in which energy is released by the joining of two atomic nuclei, and

  — through fission, in which energy is released by splitting atomic nuclei.

- Sometimes it takes a whole series of machines to convert energy into useful work.

LEARNING ACTIVITIES:

Students may:

- Research and write reports on the processes through which energy is changed into useful work.
- Design a functional machine or a "Rube Goldberg" contraption that illustrates potential-to-kinetic transformations.
- Write essays on the relationships between man and machines.
- Experiment with simple machines such as the inclined plane, pulley and lever to demonstrate how they make our work easier for us.
- Research and write reports on the history of the earliest machines and how they were used.

Concept C. The Importance of Energy

INSTRUCTIONAL OBJECTIVE:

To make students aware of the effect of energy on the evolution of civilization.

POINTS FOR EMPHASIS:

- Earliest man relied on his own energy (muscle power) to do the work needed to meet his basic needs. Nearly everything was made without the help of fire, animals, water currents, wind, chemical energy, or machines of any kind.
- Civilization is a product of man's continuous search to find nonhuman sources of energy to perform useful work. By utilizing nonhuman energy sources, man has been able to do things which he could not have done using his own muscles. Nonhuman energy sources have enabled man to accomplish work more efficiently.
- Technology evolved as man sought new and more efficient ways of using nonhuman energy sources to perform useful work.

LEARNING ACTIVITIES:

Students may:

- Write a paper describing how the roles of family members have changed as a result of the use of nonhuman energy sources.
- Write a paper on how energy affects their lives.
- Write a science fiction article focusing on future technology as it may apply to energy utilization.
- Research and dramatize what life would be like today if we did not have the benefit of *any* machines.
- Discuss which machines that our parents didn't have simplify our work today.
- Discuss how machines may have complicated our lives. Is man now a slave to his machines?

UNIT 2: ENERGY SOURCES

UNIT PURPOSE:

To make students aware of the scope of energy sources available on this planet and of the relative advantages and disadvantages of utilizing each of these sources.

ENABLING CONCEPTS:

A. Characteristics of "good" energy sources

B. The energy sources used today

C. Energy sources of the future

Concept A. Characteristics of "Good" Energy Sources

INSTRUCTIONAL OBJECTIVE:

To provide students with a set of criteria for judging the relative desirability of each energy source.

POINTS FOR EMPHASIS:

- Although everything has energy, not everything can be changed into useful work. Substances must have certain characteristics in order to be "good" energy sources.

  Characteristics:

  1. The energy source should have a high energy value.
  2. A large supply of the energy should be available.
  3. The supply should be easy to process.
  4. The energy supply should be storable and transportable.
  5. The extraction and utilization of the energy source should not have negative environmental effects or threaten our health or well-being.

- There is no perfect energy source. In order to compare the relative desirability of energy sources, we must consider the advantages and disadvantages.

LEARNING ACTIVITIES:

Students may:

- Design a matrix for comparing the relative desirability of various energy sources. The matrix should incorporate the five characteristics given in the instructional development section. (It might also include additional characteristics which they have thought of.)
- Design a process for rating the relative desirability of the energy sources. One recommended procedure would be to:

  1. Compile data on all five characteristics for each energy source;
  2. Rank the energy sources for each characteristic on the basis of desirability and assign numbers to the energy sources, giving the least desirable energy source the lowest number;

3. Add up the total characteristic ratings for each energy source; and

4. The energy source with the highest total should be the most desirable.

- Research and present illustrated reports on how people throughout history have met their needs for energy. Discuss why some of these sources may *still* be in general use today while others are no longer used.
- Build an illustrated time line to show the development and use of energy sources.

Concept B. The Energy Sources Used Today

INSTRUCTIONAL OBJECTIVE:

To make students aware of the major energy sources utilized today and to emphasize the fact that these are nonrenewable.

POINTS FOR EMPHASIS:

- Many different sources of energy are available to us.
- There are two basic categories of energy sources: renewable and nonrenewable.
- The major renewable energy sources are direct solar radiation, the heat of the earth, wind, and tidal energy.
- The major nonrenewable energy sources are fissionable elements yielding nuclear energy, and fossil fuels (coal, oil, and natural gas).
- Today, our major energy sources are:
  - — oil (44%)
  - — natural gas (32%)
  - — coal (17.5%)
  - — hydropower (4%)
  - — nuclear power (1%)
  - — wood (1.4%)
- Today's technology is geared to using nonrenewable fuels.

LEARNING ACTIVITIES:

Students may:

- Label and make explanatory charts to accompany displays of fossil fuels.
- Identify through reading and map construction where fossil fuel resources are located throughout the world. Use this information to study world trade, alliances, and conflict among nations.
- Research and report on supply and demand studies.
- Research and report on the contributions of representatives of different nations to energy technology.
- Analyze and discuss the problems of allocation in the United States and among the nations of the world.

- Determine costs for extracting, converting and transporting the various types of fossil fuels.
- Write editorials that explain why we depend so heavily on fossil fuels, what dangers are involved in this dependence, and what we can do about it.
- Compare the relative desirability of the major and minor energy sources used today, using the matrix and rating process developed earlier in this unit.

Concept C. Energy Sources of the Future

INSTRUCTIONAL OBJECTIVE:

To acquaint students with possible alternative energy sources for the future.

POINTS FOR EMPHASIS:

- Some of the major continuous or renewable energy sources available to us are

    I. Solar radiation

        A. Directly utilized by means of

            1. Optical devices such as reflectors, lenses

            2. Photochemistry, photoelectricity, and thermoelectricity

        B. Indirectly utilized through

            1. Photosynthesis, upon which living organisms depend for food and which, in addition, provides many useful materials (e.g., wood and other building materials, rubber, fibers as well as fuels like wood, alcohol, and turpentine extracted from vegetation)

            2. Use of

                a. Water raised by the sun, moved by the winds, and caught on the descent

                b. Winds

                c. Difference in temperature between atmosphere and the earth ("the heat pump") and the ocean

    II. The heat of the earth tapped through volcanic vents

    III. Tidal power

- Research is now being done to harness the following energy sources for the future:

    — Fossil fuel sources: oil shale, tar sands, and coal gasification

    — Natural or continuous sources: geothermal, solar, tidal and wind

    — Other sources: hydrogen, fuel cells, magnets, hydrodynamics, burning of trash, nuclear fission (breeder reactors), and thermonuclear fusion

LEARNING ACTIVITIES:

Students may:

- Research and report on current explorations for new energy sources and methods for harnessing these new energy sources to perform useful work.

- Research and prepare a debate or panel discussion on the positive and negative aspects of some of the newer energy sources. (250,000-year life of radioactive plutonium might be considered rather dangerous.)
- Research and report on the methods which are being proposed to improve use of fossil fuels.
- Study the waste factors in the conversion and use of present day fuels and present oral reports.
- Study and discuss the careers of scientists and technologists whose work deals with energy exploration.
- Conduct an energy education fair displaying student demonstrations and experiments dealing with learning about all sources of energy.

UNIT 3: THE ENERGY SITUATION TODAY

UNIT PURPOSE:

To make students aware of the major factors influencing the energy situation today.

ENABLING CONCEPTS:

A. How energy is used in the United States today

B. The domestic supply of fossil fuels in the United States today

C. Factors affecting the availability of fossil fuels in the United States today

D. What we can learn from the energy crisis

Concept A. How Energy Is Used in the United States Today

INSTRUCTIONAL OBJECTIVE:

To make students aware of the major users and uses of energy in our country today and of the far-reaching effects an energy shortage has on these areas of use.

POINT FOR EMPHASIS:

- Energy is so much a part of our lives that, if we have a problem with our energy supply, most aspects of our lives are quickly affected.

LEARNING ACTIVITIES:

Students may:

- Research and write papers on one of the following:

  The process of converting electricity from various energy sources

  The benefits and drawbacks of using electricity as an energy source

  What measures can be taken to reduce the amount of fossil fuels wasted through the generation of electricity.
- Find out how electricity is generated in or for their community. It would be valuable either for the students to visit the local power plant or to arrange for a guest speaker from the local power company to describe how electricity is generated for the community, what measures are being taken to improve the efficiency of the conversion processes, and how individuals can conserve electricity.
- Research newspaper or journal articles for evidences of an energy shortage either on a local or national level.
- Find out how much money is spent per month by their school for electricity, fuel for heat, and any other energy-related expenditure. Design a campaign to save energy within the school. After one month, compare the amount of money spent before and after the campaign and discuss the outcomes. If the expenditures are lower after the campaign, discuss how much of this reduction might be due to energy-saving efforts and how much might be due to warmer outside temperatures, school vacations, or other variables. A similar project might be carried on within the home.
- Find out where the phone company gets its electricity.

Concept B. The Domestic Supply of Fossil Fuels in the United States Today

INSTRUCTIONAL OBJECTIVE:

To make students aware that our supplies of fossil fuels will not last forever. Current fuel shortages are a result of shortages in the availability of fossil fuels as well as shortages in our reserve supplies of fossil fuels.

POINTS FOR EMPHASIS:

- All the major sources of energy are fossil fuels.
- Current energy shortages are not a result of a total depletion of our domestic reserves.
- Current energy shortages have resulted because supplies of domestic fossil fuels have not been made available fast enough to meet the tremendous increase in demand for them.

LEARNING ACTIVITIES:

Students may:

- Research and discuss some of the problems involved in extracting reserve supplies of oil, coal, and natural gas.
- Write a newspaper article on the energy resources available in Ohio, how long the reserves of fossil fuels in Ohio will last, and what measures can be taken to extract and utilize these reserves more efficiently. Include a discussion of the waste factors in the conversion and use of present day fuels.
- Research the various methods for extracting oil, coal and natural gas. The findings may be reported graphically through posters, charts or models and the advantages and disadvantages of each method discussed.

Concept C. Factors Affecting the Availability of Fossil Fuels in the United States Today

INSTRUCTIONAL OBJECTIVE:

To make students aware of the factors affecting the availability of fossil fuels in the United States today and of possible solutions to the problem of availability.

POINTS FOR EMPHASIS:

- The key factors affecting the availability of fossil fuels in the United States today are nationwide economic policies, environmental legislation and nonfuel uses of fossil fuels. Nationwide economic policies have kept the price of energy low in this country, much lower than in other nations. The fact that energy prices are lower in this country has had the most damaging effect on the availability of domestic petroleum and natural gas.
- Low price policies have encouraged American oil companies to sell their products for higher prices to foreign countries and to increase foreign energy supplies through exploration and expanding refinery capacities in those countries.
- Low price policies and severe governmental regulations have discouraged American industries from further exploration for new resources, and from expansion of refinery capacities in the United States.

- Environmental legislation has affected the current availability of domestic energy supplies. Also, there are groups of concerned citizens who oppose the construction of nuclear plants for reasons of safety. Many others oppose coal mining methods that scar and leave the land unreclaimed.
- Another factor which has affected availability of fossil fuels is the tremendous increase in the demand for these energy sources to be used for nonfuel purposes. For example, gas is used in the manufacture of synthetic rubber, oil and water-based paint, dishes, indigo dyes, paper coatings, plastics, explosives, carbonated beverages, antifreeze, aerosols, films and vinegars.

LEARNING ACTIVITIES:

Students may:

- Study and report on legislative measures dealing with energy. Discuss the pros and cons of these proposed policies.
- Research and report on the effects of governmental air quality control on the use and availability of coal, oil and natural gas.
- Write news articles on governmental policies that both encourage the development of domestic energy supplies and yet maintain environmental standards.
- Have a panel discussion on the relative importance of using nonrenewable fossil energy sources as fuels versus saving them for nonfuel purposes.
- Discuss the alternatives in the manufacture of various products if nonrenewable fossil fuels are reserved strictly for fuel purposes.
- Discuss the positive and negative aspects of lowering air quality control standards for automobile manufacturers, steel manufacturers, and other industries in the interest of conserving fuel.
- Make recommendations for legislation that would encourage exploration for new energy reserves in the United States as well as the expansion of domestic refinery capacities. Base recommendations on current journal and newspaper articles and interviews with relevant resource people.
- Discuss the responsibility of the American oil industries in helping to solve the energy problem.

Concept D. What We Can Learn From the Energy Crisis

INSTRUCTIONAL OBJECTIVE:

To make the students aware of what the energy crisis is all about and what we can learn from it.

POINTS FOR EMPHASIS:

- The following circumstances set the stage for the energy crisis:

  the constantly increasing demand for more and more oil within the United States,

  domestic supplies of oil which were too low to meet the domestic demand, and

  the need to import oil and natural gas to meet energy requirements.

- The Middle East oil embargo heightened the impact of our growing energy problem.
- The energy crisis has emphasized three needs clearly:
  1. The necessity for our nation to become self-sufficient in meeting our energy needs.
  2. The necessity of our finding new, renewable energy sources and developing feasible techniques for their utilization so that we are prepared when our supplies of fossil fuels are exhausted.
  3. The need to conserve our fossil fuel supplies as long as possible so that we have more time to research and perfect techniques of utilizing new energy sources.

LEARNING ACTIVITIES:

Students may:

- Interview members of their community to determine what they feel are the cause and the significance of the energy crisis. On the basis of the data the students collect, they may write a newspaper article which will help to clarify the energy crisis for the community.
- Write an editorial on "What's Good About the Energy Crisis."
- Have a panel discussion on the importance of conserving our fossil fuels to
  - — allow us more time to develop new energy sources as fuels, and
  - — save fossil fuels for nonfuel production purposes.
- Develop and utilize inventories to determine how energy is wasted at home and in public places.
- Write a paper on the problems of convincing *all* citizens that there is an energy crisis and that *each* must make personal sacrifices to conserve energy. Propose solutions to overcome these problems.
- Discuss the dynamics of human interaction in terms of the energy crisis and its short and long range solutions. Include self-interest as compared to cooperation on an individual, national and international basis.
- Simulate a Senate subcommittee investigating the possibilities of outlawing night baseball, Indianapolis 500, domed stadiums (like the Astrodome), late night TV, and other energy-consuming recreation.
- Petition grocery stores to stop wrapping and packaging food in useless containers—heads of lettuce in polyethylene, pork chops on styrofoam trays which then are wrapped, and the like.
- Conduct and publish a study of how businesses and industries are cutting back on energy use. Prepare a similar study on energy cutbacks by institutions such as schools and hospitals.
- Use statistical data to predict energy consumption trends.
- Develop value objectives for forming an individual energy conservation ethic.

UNIT 4: WHAT WE CAN DO TO IMPROVE THE ENERGY SITUATION OF TODAY AND OF THE FUTURE

UNIT PURPOSE:

To make students aware of what needs to be done and how they may help to improve the energy situation today and in the future.

ENABLING CONCEPTS:

A. What we can do to ease the energy shortage today

B. What we can do to prepare for the future

Concept A. What We Can Do to Ease the Energy Shortage Today

INSTRUCTIONAL OBJECTIVE:

To make students aware of how they can ease the energy shortage today through helping to decrease the demand for energy.

POINTS FOR EMPHASIS:

- It is important to conserve our fossil fuels for two major reasons:

  to give us more time to identify new energy sources and to develop the technology required to convert these new energy sources into useful work, and

  to save as much of our fossil fuel supply as possible for nonfuel purposes.

- As individuals we can do many things to conserve energy. For example, we can boycott or discourage use of machines that are not designed to use energy efficiently.
- It is important to compare how efficiently different brands of a product use energy before deciding which brand to buy. If everyone did this, it would encourage manufacturers to develop products which use energy efficiently.
- Another very important factor contributing to the tremendous demand for energy is that many Americans waste energy. We tend to waste energy by using nonhuman energy to do things that we could do just as well ourselves or to produce things that we don't really need, and by such things as leaving the lights or TV on when we are not using them.

LEARNING ACTIVITIES:

Students may:

- Research and prepare reports on the relative efficiency of different brands of the same product. Each student (or small group of students) may research a different product and design and print a report on the composite findings of the class to distribute to other students and parents. (Student version of *Energy Consumer Report*.)
- Design brochures to inform the public about what they can do to ease energy demand.
- Set up personal energy conservation goals. Conduct periodic checks to determine whether or not those goals are being attained.

- Consult issues of *Consumer Report* or other similar publications to investigate the means by which consumer products are tested for efficiency. Some of these methods may then be adapted so that students can conduct simple tests for efficiency within the classroom.
- Hold class and student council meetings to propose and adopt, through student vote, methods of conserving energy within the school. Elect a school energy conservation committee.
- Conduct and publish the results of community surveys. Example: how many cars pass a designated point with a driver but no passengers?
- Learn to read electric and gas meters to determine home use.

Concept B. What We Can Do to Prepare for the Future

INSTRUCTIONAL OBJECTIVE:

To make students aware of what needs to be done and how they can help to insure the availability of energy sources in the future.

POINT FOR EMPHASIS:

- Regardless of how well we conserve our nonrenewable energy sources, eventually they will run out. We need to start to prepare for the future now. We need to research and develop renewable energy sources for the future. Developing new, renewable energy sources sufficient to meet our national needs is a phenomenal task that will require a great deal of time. Conserving energy today will give us more time, but only a wholehearted national commitment to energy conservation will solve the problem.

LEARNING ACTIVITIES:

Students may:

- Write editorials to urge the general public to conserve energy.
- Interview community members to find out how they feel about the taxpayer's dollars going for research related to finding new energy sources. On the basis of the interviews, students may write editorials to convince the community of the importance of research in this area.
- Write to their congressman to find out what legislation has been passed or is being proposed to help insure adequate, available, usable energy sources for the future.
- Talk to service clubs, individually or in teams, concerning the energy problem.
- Develop individual science projects related to the various aspects of the energy problem.
- Interview members of the community who work in energy-related occupations. Use the telephone directory and want ads as a survey source to identify energy-related careers.

SECTION III

PHYSICAL FACILITIES CONSIDERATIONS

ENERGY AUDITS

The word audit conjures up the picture of an accountant pouring over records in search of errors in order to balance the books. An energy audit also is concerned with a balancing and correcting process. In order to correct (or improve) a school building energy problem, we must have an energy assessment of that building, an audit. The Federal Energy Administration describes an audit as a procedure used in determining energy and cost savings from the installation of a particular modifcation in a building or industrial plant.

Three methods of identifying energy conservation measures in the schools are the following:

1. a computer simulation model known as Public School Energy Conservation Service;
2. a program known as the miniaudit;
3. a total engineering analysis, the maxi audit.

The next several pages describe these audits as well as suggesting guidelines for starting a district energy program.

MINI-MAXI AUDITS

MINI-AUDIT DESCRIPTION

"Mini-Audit" is a descriptive term that has evolved from the recently developed concept of cursory, on-site inspections of industrial, commercial, and public buildings. The concept has been used extensively by the Minnesota Energy Agency with the cooperation of several interested Minnesota utility companies and engineering firms. Mini-Audits are one to two hour surveys that are conducted by individuals or teams of specialists who walk through a facility observing and analyzing building structure, HVAC systems, operational practices, and other factors that relate to energy consumption. Two (2) major areas of possible energy savings receive special attention: measures that can be implemented quickly and at little or no cost, usually in the operations and maintenance area (O & M), and retrofitting possibilities that will require some, though not extensive, capital investment.

For school buildings, the Mini-Audit teams are best made up of a professional HVAC systems engineer, a technical representative of the gas and/or electric utility or fuel company that supplies heating fuels to the school, the chief operating engineer for the building, and one or more administrators from the school or school district. It is desirable that at least one of the team members has had prior experience in Mini-Audit inspections.

In some localities, utility companies will participate in Mini-Audit surveys for schools at no cost or for only the price of a service call. In other areas, knowledgeable public officials or agencies may be willing to participate at little or no cost. But, even in those areas where the Mini-Audit must be contracted for from a consultant, the cost probably will not exceed $200.

The Mini-Audit necessitates at least some involvement on the part of operating personnel at a facility. This involvement by itself may supply a degree of motivation necessary for accomplishing energy conservation. The Mini-Audit also frequently establishes contact and lines of communication between the school and local utility personnel. To the extent that these contacts are on-going, they may be beneficial for both the utility and the school.

The Mini-Audit team seeks to understand current operating and maintenance practices for the building, surveys and heating and/or climate control system, takes careful note of the building type, age, and state of repair, looks at the condition of window systems, doorways, etc., and generally attempts to determine how the building is put together and how it is operated.

As soon as possible after completion of the Mini-Audit survey, the team prepares a report. This report contains a summary of the conditions that were found in the school and suggestions and recommendations for any changes in operating practices, building components, and instrumentation that should result in energy savings. (Sample copies of Mini-Audit reports are attached.)

The Mini-Audit system is different from the PSECS system in that almost all of the information on which recommendations are based comes from the direct observation of the team members. This is why adequate training and experience are so necessary. No significant information other than a description of "standard" operating practices is supplied by school personnel.

Since Mini-Audits do not involve an attempt on the part of the audit team to quantify estimated energy or dollar savings, it is difficult if not impossible to perform a cost/benefit analysis. The Mini-Audit tends to concentrate more than the other types of audits on operation and maintenance modifications for which there is no cost or at most only slight cost; thus, savings can often be made without any significant investment. In the face of such potential savings, these audits appear to be an excellent investment in time and effort.

When the Mini-Audit report has been prepared, it is presented to school personnel. It contains many energy conservation measures that are, for the most part, quickly and easily implemented by operating personnel. Experience has shown that administrators and operating engineers are generally eager to receive the results of the Mini-Audit. Mini-Audit reports have proven to be a useful tool for implementing a variety of no-cost and low-cost conservation measures and they also have the ability to give an indication of the need for a more extensive maxi-audit.

MAXI-AUDIT DESCRIPTION

The most comprehensive examination of the energy use patterns in a school building and the most complete identification of economical conservation measures is obtained by the Maxi-Audit. In the Maxi-Audit method, an engineering and/or architectural consultant is contracted to conduct a thorough study of the physical plant, its operating systems, use patterns and historic energy consumption data to determine the potential for energy savings.

The consultant is responsible for obtaining accurate information on many aspects of building operation and energy use, including: appropriate weather and climate data, actual quantities of energy used (electricity and heating fuels) during an appropriate time period, use patterns for the building and its major component parts, construction details for the building and its HVAC systems, instrumentation and its functional accuracy, and significant details in the ways the building systems are operated by students, staff, and operating engineers. This information must be gathered by the consultant from a variety of sources and must be adequately verified before calculations are made.

A properly conducted Maxi-Audit uses a variety of tools to analyze present energy consumption and potential energy savings in several areas of building operation. These areas include: space heating and cooling, ventilation (air handling), fluid handling, domestic water heating (appliances), illumination systems, and building structure.

The choice of exact procedures used in the performance of a Maxi-Audit is largely up to the consultant. Experience has shown that the majority of architectural engineering firms feel that the use of a computer simulation model is most appropriate for determining "guideline" energy budgets and potential energy use levels. Other consultants have used manual computations to good advantage. If the school district has strong feelings about the procedures by which work is to be done, such specifications should be detailed in the contract.

It appears from reviewing the Chicago Project Maxi-Audits that those analytical methods employing computer simulation models resulted in more comprehensive results than did manual computations. As computer simulation models used in energy work become more numerous, more sophisticated (and reliable) in the years ahead, the advantage of their use over manual methods should increase.

Regardless of whether manual or computer methods are used, the comparison between actual energy consumption and the calculated guideline "energy budget" highlights areas where conservation measures may effect savings in dollars and energy.

One distinct advantage of the Maxi-Audit procedure over either the Mini-Audit or the PSECS method is that costs specified for any recommended retrofit work will be based on local considerations rather than on national averages. With accurate local costs, the projected savings in fuels can be better weighed against capital investments for each recommendation.

In the computation of potential cost savings (and pay-back periods) one significant element is in determination of the cost of energy. The consultant must decide whether to value each form of energy at its historic cost, at rates in effect at the time of the Maxi-Audit, or at some inflated or inflating rate. Schools that have the capacity to use alternative fuels pose yet another problem. Should energy costs be based on the historic fuel mix or on a changed or changing fuel mix? In those many cases where natural gas is expected to be available in lower quantities for boiler fuel in the months and years ahead, it seems unrealistic to base pay-back periods on the historic fuel mix — which probably consisted largely of inexpensive natural gas. Most of the Maxi-Audits completed to date have apparently calculated energy costs at the rates and mixes in effect at the time of the audit. The school district contracting for a Maxi-Audit should specify the way in which they want projections of future fuel costs to be handled.

The form and format of the final report of a Maxi-Audit will generally be determined by the consultant, but it should include — as a minimum — the following: (1) a complete inventory of energy-using equipment. One of the most valuable parts of the Maxi-Audit is the inventory of energy-using equipment in the facility. Without knowing the relative energy drain caused by each piece of equipment, it is difficult for personnel to do their best at reducing waste; (2) the calculated energy budget for the building; (3) current deviation from the calculated energy budget; (4) fuel and cost savings that would result from recommended changes in operation and maintenance practices; and (5) capital investment and pay-back periods for recommended retrofitting measures.

The total energy and/or cost savings estimates identified by the nine (9) Maxi-Audits performed as part of the Chicago Project ranged from 10 percent to 40 percent. The size of predicted energy savings is not necessarily related to the diligence with which the Maxi-Audit was performed. Several of the Maxi-Audit reports made mention of areas in which energy use reduction was *not* possible or economical due to extenuating circumstances, thus eliminating waste effort in areas where no conservation potential existed.

The usability of the Maxi-Audit is improved if recommendations for conservation measures are prioritized and summarized. The prioritization should separate O & M recommendations from those requiring retrofit expenditures. In the area of retrofit or capital modifications, the most cost-effective measures should be listed first.

Upon receipt of a Maxi-Audit report, school personnel have the opportunity to make decisions based on the best possible projects of energy savings and their dollar impact. Suggestions in the O & M area can be implemented almost immediately. Capital investment recommendations can be accomplished as school district funds are made available.

In selecting a consultant to perform a Maxi-Audit for a school building, the relative qualifications of available engineering and architectural firms should be carefully considered. Prior experience with energy management/energy conservation programs is highly desirable.

Maxi-Audits are not inexpensive — usually costing $3,000 to $10,000 or more — yet they provide energy information for a given school building at a level of detail that can be obtained in no other way, and often return their cost in a surprisingly short time.

As consultants become more aware of the processes involved in performing a Maxi-Audit, the contract prices should level out and may well decrease significantly.

School districts might be able to get a better idea of the potential usefulness of a Maxi-Audit if they use a model contract. The model contract should state in simple, understandable terms the types of information the district would be required to supply (school obligations) and the types of information that would result from a Maxi-Audit (consultant obligations).

MINI-AUDIT

C. E. MacDONALD MIDDLE SCHOOL (TYPE 3)
1601 Burcham Drive
East Lansing, Michigan
May 14, 1975

by

Minnesota Team
W. Herbert Doty - Minnesota Gas Company
Dale M. Pederson - Northern States Power Company
Samuel J. Stewart - Minnesota Energy Agency

Observers
Cernyw K. Kline - State Energy Office, Michigan
James R. Padgett - State Energy Office, Michigan
John L. Baird - HEW/FEA, Washington, D.C.
Barry Gale - FEA, Washington, D.C.
Harold Carter - Consumers Power Company, Lansing, Michigan
Ray Jusick - Board of Water and Light, Lansing, Michigan
LeRoy Davis - State Department of Education, Michigan
J. P. Ward - East Lansing School District

SCHOOL MINI AUDIT FORM

Name of School *C. E. MacDonald* Address *1601 Burcham Drive*

Name of School District *East Lansing* State *Michigan*

Person to Contact *Joe P. Durken, Business Manager* Telephone

Type of School *Middle*

Year Building Constructed *1968* Number of Students *900*

Gross Area *124,400* Number of Floors *2*

Type of Construction *Brick face with slag block interior*

Type of Windows and Approximate % of Wall *Single pane, non-operable about 5% glass*

Storm Windows *No*

Roof Insulation *Adequate*

Comments:

This building has a very sophisticated mechanical system. The operating crew has learned some of the operating idiosyncracies which all systems have and are attempting to do a good job. We believe the key to successful operation is "concerned daily supervision" of the "total mechanical and electrical system". We would recommend an in-house system training course for this specific system that reviews the objectives of the system, the mechanical controls needed to accomplish these objectives, the maintenance and setting of these controls, and the interaction of these controls. Rapport between operating and management staff is excellent! Training for chief's replacement should be beginning so building system continuity remains.

Most rooms interior with natural lighting in surrounding hallways.

HEATING SYSTEM

1. Type and Number of Boilers/Furnaces *Two Kewanee Scotch Marine boilers*
2. Size of Boilers *200 hp each, 8370 MBH each*
3. Type of Heating Terminal System *Steam coils in air handling units Honeywell pneumatic, hot-cold deck multizone*
4. Type of Thermostatic Control *Individual room control*
5. Steam Pressure or Water Temperature *7# steam*
6. Last Flue Gas Analysis *?*
7. Heating System Description:

On the day of the audit, the #1 boiler was running and maintaining steam pressure between 5 and 7 pounds. The #2 boiler was off and being repaired.

One of the boilers operates during the summer to provide steam to the pool heat exchanger and also to the domestic hot water heat exchangers for the gym showers, etc.

The #1 boiler was operating and cycling on and off every 3 minutes while we were observing. The boiler came on when the steam pressure dropped to 5 pounds and shut off as soon as the pressure built up to 7 pounds. The boiler started and stayed on low fire until the steam pressure reached 7 pounds and then shut off.

The summer space temperature is maintained between 71° and 72°F. The winter space temperature is maintained at about 68°F.

There are night stats serving clusters of rooms that are set between 60°-65°F.

Automatic steam humidity control.

Piping heat losses in tunnel areas were relatively low indicating good insulation.

Building engineers are attempting to provide comfort conditioning as economically as possible with existing controls and system knowledge.

COMMENTS:

(1) Consider reducing the steam pressure from 7 pounds during the summer months to the lowest pressure that will satisfy needs.

(2) Consider installing a small gas or electric steam boiler near the pool heat exchanger to satisfy this heating requirement and also a small gas fired domestic hot water heater in the boiler room to eliminate the need for operating the large Kewanee steam boiler during the summer months. We feel that the system as it currently operated may be inefficient during the summer because of the continuous cycling of the large boiler on low fire, the radiation losses off of the boiler and into the boiler room, and the radiation losses from the steam piping running from the boiler room to the pool heat exchanger.

(3) Consider having a competent combustion engineer make a flue gas analysis at least once each year to properly adjust the fuel/air ratio.

(4) Consider hiring engineer consultant to review entire system operation to determine if equipment is being operated as economically as possible and to recommend changes in controls or system modifications.

DOMESTIC HOT WATER SYSTEM

1. Type of System *Heat exchanger off the steam boiler*
2. Water Temperature
3. Special Use Facilities —

Pool *Yes* Kitchen *Yes*

# of Shower Heads # of Meals/Day

Comments:

The gym shower heads have 15 second self metering timers that automatically turn off. We feel this is a definite conservation measure and again commend the school for installing this type of equipment. The shower heads also appeared to have minimum water flow during the 15 seconds that they are on.

We inspected the kitchen area at 3:30 p.m. and found the entire facility vacated and all equipment off. We commend the kitchen staff for leaving the area with the lights off and all mechanical equipment off.

(1) Consider reducing the temperature of the domestic water furnished to the lavatories and to the showers to 120°F or less.

VENTILATION SYSTEM DESCRIPTION

The school has 18 air handling units automatically controlled from a Honeywell panel located in the boiler room. Within the control panel, there are timeclocks that operate the classroom and auditorium ventilation units during the day from 7 a.m. to 9 p.m.

According to the engineer, all of the ventilation units with cooling coils are set for 20% fresh air with a 55°F mixed air temperature.

The ventilation units serving the pool, locker room, shops and gyms do not have cooling coils.

One timeclock operates the gym ventilation units from 7 a.m. to 9 p.m. during weekdays. The gym ventilation unit is a 100% outside air unit with relief vents to outside.

The ventilation units are of a multi-zone type with a hot and cold deck, each having an economizer cycle with 100% outside air capability.

The multi-zone ventilation units are controlled with a hot deck maintained at 75° during the fall season and 90°-95°F during the winter season. Two pool ventilators operate 24 hours per day, 365 days per year. (Manually readjusted by building operating engineer.)

Comments:

(1) Consider increasing the cold deck temperature from 55° to 57°-60° to reduce the mechanical cooling requirement during the summer. This may have the adverse effect of raising humidity level. Consider increasing the thermostat setting during the summer months from 71°-72°F to a minimum of 75°F, again to reduce the summer mechanical air

conditioning requirement.

(2) Consider reducing the minimum outside air setting on all of the ventilation units to less than 20%, especially during the summer months when the building is not fully occupied.

(3) Consider increasing the mixed air temperature from 55° to 57°-60°, again to reduce the summer mechanical air conditioning requirement and the winter space heating requirement.

(4) Consider controlling the gym ventilation unit or units from the gym so that the units are only operating when the gym is occupied.

(5) Consider operating only one of the two units serving the auditorium-lunchroom during normal hours except when the auditorium is fully occupied. On the day of the audit, both units were running with only 4 people in the auditorium.

(6) Consider changing the timeclock settings so that the ventilation units start at 8 a.m. instead of 7 a.m. and stop at 8 p.m. or earlier instead of 9 p.m. We believe all of the units should automatically be turned off when school is out and only those units serving occupied spaces should be on during the evening hours.

(7) Consider acquiring the services of a temperature control expert to check and adjust all controls.

(8) Consider valving off the steam lines to the steam coils in each air handler during the summer months to prevent steam leakage or close valves on lines not needed at boiler room header.

(9) Consider upgrading this modern air handling system by adding enthalpy control to outside air demand. This would supercede recommendations 1, 2, 3 and make use of outside air for "free-cooling".

(10) Consider reducing pool ventilation hours.

(11) Consider heat recovery application on exhaust air from building and pool area. Pool exhaust runs 24 hours per day from air heated to 82°.

(12) Consider organizing "service and operating" school for building engineers, either in house using outside expert and trained employees or sending out certain building operators for specialized training.

AIR CONDITIONING SYSTEM DESCRIPTION

Two Trane air cooled condensing chillers are controlled from the boiler room by on-off switches. The chilled water pumps are also controlled from the same boiler room panel.

On the day of the audit, the cooling switches for each of the ventilation units with air conditioning capability were in the off position. These switches control chilled water cooling coil valves for each of the ventilation units. The chilled water pumps (one for each Trane air conditioning unit located up in the penthouse) were on the circulating chilled water throughout the building even though the individual air handling units were not calling for cooling. One of the Trane condensing units was cycling on and off to maintain the chilled water temperature setting.

The chief engineer normally turns on the cooling system during the month of April.

Comments:

(1) We suspect that even though the chilled water valves are closed there may be some leakage into the chilled water coil with the chilled water pumps running. Consider leaving the chilled water pumps off unless there is a cooling requirement for one of the air conditioning units. We believe that chilled water pumps off the air conditioning unit would also not cycle nearly as often because there will not be any cooling demand to satisfy.

(2) Consider increasing the summer space temperature from 71°-72° to a minimum of 75°F.

(3) Consult with Trane Company to determine if cooling equipment is running during all months and if chillers, fans, and heaters can be completely shut down when outside temperatures are below certain levels.

LIGHTING SYSTEM

Typical Classroom Lighting

Type of Fixtures *Fluorescent*

Watts/Sq. Ft. *Adequate*

Typical Hallway Lighting

Type of Fixtures

Watts/Sq. Ft.

Comments:

Classroom lighting levels vary from 75 ft. candles under the fixtures to 50 ft. candles between rows of fluorescent fixtures. These lighting levels are considered minimum for general classroom work. Instructors have been asked to turn lights off whenever leaving a room for more than 20 minutes. This appeared to be done in most cases.

Half of the tubes have been removed from the 4 lamp fluorescent fixtures in the hall areas without creating a hazardous condition. Ballasts have not been disconnected.

Gymnasium lighting level of 35-40 ft. candles is considered minimum for most indoor sports.

On the day of the audit, all of the lights in the auditorium were on even though it was occupied by only 4 people. In the pool area. the lights were on even though no one was using the pool. The gym lights were on even though the space was unoccupied.

We commend the faculty for turning off the lights in the unoccupied classrooms.

Comments:

(1) Consider acquiring conservation reminders such as posters and individual decals that can be located next to the light switches to alert both students and teachers that turning off the lights when not in use is their responsibility. Implement information and education programs on energy conservation.

(2) Consider removing 50% of the fluorescent tubes in the office area. Use light meter and check against minimum standards for tasks.

(3) Schedule maintenance for relamping and cleaning fluorescent fixtures.

(4) Use light colored reflective paint whenever redecorating walls and ceilings.

(5) Consider installation of switching capability in some classrooms so that half or certain rows of lights can be used as needed.

(6) Keep informed on developments in school lighting with high efficiency lighting sources such as hi and lo pressure sodium.

(7) Disconnect ballasts from fixtures when tubes have been removed. Ballasts consume a small amount of energy and will eventually burn out.

(8) Replace fluorescent tubes with low wattage type as maintenance schedule and inventory permit. (Mr. Ward is planning this now.)

BUILDING CONSTRUCTION

In the office area, the lower portion of the south exposed glass wall has been covered with polystyrene and painted masonite to blend in with the decor. This was done to reduce heat loss that was causing discomfort for the office workers. We commend the school administration for taking this action with their own staff and feel that it is very professionally done.

ELECTRICAL

Monthly demand for electrical energy is averaging around 3 watts per square foot, 12 months of the year. This seems unusually low for a new school with air conditioned areas. The KW demand of 360-400 would seem about average without air conditioning.

Considerations: Check electrical metering to determine if metering constant is correct and if all electrical load is being metered.

SCHOOL: **C. E. MacDONALD MIDDLE SCHOOL**

ADDRESS: 1601 Burcham Drive

DATES OF CONSTRUCTION

1968 Total building completed

SUMMARY OF FACILITIES	**Standard Classrooms**	**Special Rooms**
First Floor	15	Pool Gymnasium Locker rooms Adapter sports deck Cafeteria 2 Art rooms 1 Shop 1 Choral room 1 Instrumental music room 1 Audio room for vocal music 1 Electronic piano room 1 Library 2 Special Education rooms 1 Teachers' planning room and lounge
Second Floor	8	4 Science rooms 1 Homemaking room Library balcony Principal's Office Suite
Total	23	

CAPACITY 900 students

CONSTRUCTION INFORMATION

Exterior walls: Face brick with slag block interior.
Structural System: Structural steel frame with steel joist.
Heating System: Two low pressure, steam gas fired boilers. Complete building air conditioned.
Lighting: Complete building fluorescent lighted.

TOTAL BUILDING AREA 124,400 sq. ft.

SITE

Area: Approximately 38 acres
Extensive physical education fields available
Parking for 100 cars

EXPANSION

Building could be expanded to any size desired to fit instructional program.

MINI-AUDIT

of

BUFFALO GROVE HIGH SCHOOL (Type 3A)

Arlington Heights, Illinois

June 3, 1975

by:

Minnesota Team

W. Herbert Doty — Minnesota Gas Company
Dale M. Pederson — Northern States Power Company
Samuel J. Stewart — Minnesota Energy Agency

Observers

J. E. Dunwoody — State of Illinois Energy Office
Paul Gilson — Federal Energy Administration, Region 5
Mel Fisher — U. S. Department of HEW, Chicago
George L. Winter — U. S. Department of HEW, Chicago
Josh Burns — Educational Facilities Laboratories
Lyle R. Poole — Commonwealth Edison Co.
John W. Emback — Commonwealth Edison Co.
Jack Holmquist — Northern Illinois Gas
Tom Cosgrove — District 214 Physical Plant Director
Pete Walsh — Buffalo Grove High School

SCHOOL MINI AUDIT FORM

Name of School *Buffalo Grove High School*

Address *Arlington Heights*

Name of School District *Number 214*

State *Illinois*

Person to Contact *Tom Cosgrove*

Telephone

Type of School *High School*

Year Building Constructed *1973*

Number of Students *2,000*

Gross Area *300,000*

Number of Floors *2*

Type of Construction *Brick*

Type of Windows and Approximate % of Wall *Single glazing, bronze tint*

Storm Windows *No*

Roof Insulation *Minimum*

Comments:

District 214 has 8 high schools, the last 3 constructed were centrally heated and cooled.

Administration is seriously considering the purchase of an automation system to operate and monitor HVAC systems in 3 high schools, 1 of which is Buffalo Grove. They are convinced energy use can be optimized with a central automation system. Considering 203 automation points in one location. Burner alarm panel for 7 control panels plus domestic water and swimming pool water heater.

HVAC system is still being checked out and has not been tuned up.

School has reduced total energy consumption by 11% mainly by standard conservation measures — turning down lights, reducing some temperatures, and night setback.

Two electric meters, meter A and meter B. Meter A running around 290,000 kilowatt hours per month, meter B running around 250,000 in November and December. In April 245 and 290 thousand. Hours use are running 500 or more a month. Demand on the school is running 1100 to 1200 kw. Peak demands are fairly flat throughout the year. Some charting has been done to show electric demand peaks.

Building is heavily used by the community for community activities.

HEATING SYSTEM

1. Type and Number of Boilers/Furnaces *25 gas fired rooftop multizone Nesbitt heating units (RA 46262 NU)*
2. Size of Boilers
3. Type of Heating Terminal System *Hot air*
4. Type of Thermostatic Control *Pneumatic*
5. Steam Pressore or Water Temperature
6. Last Flue Gas Analysis *Believe it was checked at time of installation*

7. Heating System Description

All 25 Nesbitt rooftop units contain gas fired heating furnaces.

Night setback to 60°F at 8:30 p.m. during the winter months.

Winter temperatures are maintained at 71-72°F and summer temperatures at 76°F.

School management considering enclosing rooftop units in penthouse; however, this may not be practical because gas fired units are direct vented through sides.

Comments:

(1) Consider having a competent combustion engineer make a flue gas analysis at least once each year to properly adjust the input and check combustion.

(2) Consider making the energy consumption and cost data available to the school principal and chief operating engineer so that they can evaluate and compare against previous months, normal budget, and perhaps against other schools.

(3) Consider changing to night setback temperatures at 5:00 p.m. instead of 8:30 p.m. in those spaces not occupied during the evening. The gym and field house could be maintained at 64°F during the day cycle.

(4) Consider lowering the winter space heating temperatures from 71-72°F to 68°F.

DOMESTIC HOT WATER SYSTEM

1. Type of System *Bryan L40W-WT 2,700,000 BTU gas fired domestic hot water heater*
2. Water Temperature *Set 170°F* for the large storage tank. 155°F leaving, 140°F return
3. Special Use Facilities

Pool *Yes* Kitchen *Yes*

# of Shower Heads *?* # of Meals/Day *?*

Primary domestic hot water pump from hot water heater to storage tank runs continuously. Secondary domestic water pump from storage tank throughout building also runs continuously.

Domestic hot water system has excellent insulation on the hot water piping.

Comments:

(1) Consider reducing the storage tank water temperature from 155°F to 120°F or less. The pool may require a small electric booster heater.

(2) Consider operating both primary and secondary pumps off one of the timeclocks located nearby to eliminate night and weekend operation.

(3) Consider having a competent combustion engineer make a flue gas analysis at least once each year to properly adjust the input and check combustion.

(4) Consider operating primary pump from tank thermostat on "demand". This would reduce flue loss.

VENTILATION SYSTEM DESCRIPTION

Twenty-five Nesbitt multizone rooftop units provide space conditioning for the school. Eight units are straight heating and the balance are heating and cooling. The gym, field house and shops are not air conditioned. Approximately 180,000 sq. ft. cooled.

Each combustion heating-cooling unit has the capability of supplying air at different temperatures to individual rooms. A room thermostat controls the hot deck and the cold deck damper position to maintain the desired room temperatures. When in the air conditioning mode, air is supplied at about 55°F and reheated at the individual rooms with electric reheat coils. We believe the hot deck dampers are closed resulting in all supply air passing over the cold deck cooling coils. According to the engineer, reheat is used only during the summer months to maintain temperatures.

Minimum fresh air setting on outside air dampers at 22-28%.

We observed the following:

Unit #17 —Minimum outside air, recirculating 100%, exhaust damper closed. Four separate gas fired burners, first stage — Burners 1 & 2, second state — Burners 3 & 4.

Unit #16 —Kitchen unit — Air conditioning compressor on.

Unit #15 —Guidance area (classrooms) — air conditioning off. Minimum outside air, recirculating 100%, exhaust damper closed. Apparently minimum setting on fresh air damper satisfactory for 68°F outside temperature. Supply fan 25 hp, exhaust fan 5 hp, condenser fan 2 hp. Heating input 1040 MBTUH, output 780 MBTUH. Direct expansion 2-stage cooling.

Seven control panels each controlling up to 4 rooftop units are located throughout the building. Each unit has off-automatic control, off-automatic outside air damper control, and off-automatic refrigeration control. Each control panel has one 7-day timeclock set for 4-5 a.m. start and 8-8:30 p.m. stop for normal classdays. Night classes run until 9-9:30 p.m. Each fan system has "fan on" light, "dirty filter" light and "temperature abnormal" control light. The #8 control panel had all off-automatic switches in the automatic position. Ventilation control switches the automatic control position and 3 of the 4 refrigeration switches in the off position, one on.

Exhaust fans are controlled from 35 different locations.

Comments:

(1) Consider a training program for operating engineers to make them aware of how the HVAC system (primarily temperature control) was designed to operate. Include optimization of energy via temperature control.

(2) Consider raising summer cold deck temperature from 55°F to 58-60°F to decrease summer air conditioning requirement and also to decrease electric reheat.

(3) Consider turning off electric reheat coils during the summer with increased supply air temperatures; reheat may not be needed.

(4) Consider decreasing winter cold deck temperatures to the point where some rooms can be maintained no warmer than 68°F.

(5) Consider reducing the minimum settings on all fresh air dampers, include the gym and field house.

(6) Consider cycling the exhaust fans to reduce the amount of conditioned air discharged outside. The rooftop units we inspected were exhausting no air which indicates all of the fresh air is being exhausted resulting in possibly a negative pressure condition.

(7) Consider starting ventilation fans at 7 a.m. instead of 4-5 a.m. and stopping at 7 p.m. instead of 8-8:30 p.m.

(8) Consider operating all ventilation fans in the warm-up cycle (no outside air) until 8 a.m. each day and after 5 p.m. each day.

(9) Consider installing a separate timeclock(s) for exhaust fans so that they can be operated shorter hours.

(10) Consider hard wiring all remote control panels into one central panel.

(11) Consider not operating the gym and field house ventilation units when not occupied. On the day of the audit, all gym and field house air handling units were running with no occupancy. During the heating season these 100% outside air units consume a fantastic amount of energy.

LIGHTING SYSTEM

Typical Classroom Lighting

Type of Fixtures *Fluorescent 4-Tube Fixtures (Lightmeter used when tubes removed)*

Watts/Sq. Ft.

Typical Hallway Lighting

Type of Fixtures *Incandescent and Fluorescent*

Watts/Sq. Ft.

Classroom C-102 occupied by 1 person with all lights on. Every other fixture has 2 tubes removed, lighting level at 80 ft. candles. Single light switch per classroom. Ballasts have not been disconnected.

Library has mercury vapor lighting. Lighting level has not been reduced, however, as bulbs burn out they are not replaced. Single switch for the entire library.

The English fine arts classrooms has every other row of ceiling fluorescent lighting disconnected. Most of the classrooms have at least 25% of the tubes removed.

Lunchroom area has incandescent lighting, all on. Black ceiling. Very little reflectance.

Resource room operating with half of the lights switched off. Still has lighting level of about 75 ft. candles.

Gym and field house were both unoccupied with all mercury vapor lights on. The field house has good light from outside on these exposures.

The swimming pool is a cooperative arrangement between the city and the school. The swimming pool has excellent skylights plus fluorescent lighting — unoccupied with all lighting on. Approximately 40 fixtures, 4 tubes each.

The school building does have a few skylights.

Comments:

(1) Consider replacing the hallway incandescent lighting with smaller bulbs as they burn out.

(2) Consider removing some fluorescent tubes from office areas.

(3) Consider removing 50% of the tubes from the fluorescent fixtures in the domestic hot water heater room.

(4) Consider removing 50% of the tubes from the fluorescent fixtures in the storage room adjacent to the water heater room.

(5) Consider painting lunchroom ceiling with a light color when redecorating to improve light reflectance.

(6) Consider installing timers on gym and field house lighting systems that will automatically shut off lights after each class.

(7) Consider acquiring energy conservation reminders such as posters and individual decals that can be located next to the light switches and on bulletin boards to alert both teachers and building staff that turning off the lights is their responsibility. Review energy conservation procedures periodically.

(8) Consider the installation of photocell and timeclock to operate some of the swimming pool lights during occupied hours.

BUILDING CONSTRUCTION:

Fixed windows. Some entrances have a vestibule.

MODEL MAXI-AUDIT CONTRACT FOR CONSULTANT SERVICES

DUTIES OF CONSULTANT

Consultant shall make a comprehensive energy study of
____________________________________ school
located at ____________________________________

This study will include a detailed list of recommended energy conservation measures separated into the following grouping of energy using functions.

Space Heating — Boiler Room
Domestic Water Heating
Ventilation (temperature control)
Air Conditioning
Lighting
Building Structure
Miscellaneous

All of the energy used in the school can be assigned to the several functions described above. Because these functions are interrelated in several ways, there may be some overlapping of recommended conservation suggestions. Conservation measures for each function should be categorized in two areas:

(1) Measures that can be implemented quickly at little or no cost, usually less than $200.00 in the Operations and Maintenance (O&M) area:
(2) Measures that require substantial retrofitting and will entail some—though not extensive—capital investment.

Consultant shall estimate investment required for item 2 measures.

Maxi-Audit (Description)

In the absence of records from extensive submetering systems, it is necessary to conduct an inventory of energy-using apparatus to calculate the design loads under existing operating conditions to project the normal monthly use of energy in a respresentative weather year, and to divide the recorded monthly purchases of electricity, gas, oil, coal, steam, etc. among the functional uses in accord with prudent judgment based on the inventory and calculations.

A careful survey of the building facilities must be undertaken to identify the energy-using apparatus, to *measure or estimate* the rate of energy use at each device and to determine the circumstances that control the frequency and duration of operation and the part-load response.

It is helpful to start with a set of "as built" construction drawings, accurate test and balance data, definitive temperature control system diagrams and a descriptive sequence of operations. In any event, it is necessary to determine: the physical dimensions of the building; construction materials used; compass orientation; shading effect of adjacent buildings or permanent plantings; applicable ventilation requirements; complete data on illuminating systems, people occupancy, appliances and equipment used in the building. From these data the Design Heating, Ventilating and Cooling Loads can be calculated for the extreme outdoor weather conditions, winter and summer, and the desired interior temperatures and humidity. Detailed instructions on a standard method of performing this calculation are included in ASHRAE Handbook of Fundamentals, 1973.

The results of design load calculations can be used to estimate the annual heating and cooling loads *by manual or computerized procedures* that simulate operational conditions, the influence of hours of occupancy and a model year weather occurrence including available sunshine and the annual 8760 hourly occurrences of dry bulb and wet bulb conditions.

The inventory of energy-using apparatus should include the equipment used for functions other than adding and removing heat. Each such item or grouping of items should be assigned a maximum rate of energy consumption and a program of start, stop and part-load performance for each month. These data are then combined to produce the monthly and annual BTU and KWH of energy used for operation of these Air Handling, Fluid Handling, Hot Water Heating, Appliance, Process, Transportation, Interior and Exterior Illuminating Functions.

The total monthly BTU of heat energy required for all heating functions should then be divided by appropriate monthly fuel conversion efficiency factors to determine net heating fuel energy required per month in a normal year.

The total monthly heat gains and hours of refrigeration plant operation for each month must be used to produce the monthly KWH of electricity (and BTU of heat, where applicable) to absorb the building heat gains and transfer them to the environment.

After the estimated energy use has been calculated for applicable energy use functions, the monthly records of electricity, gas, oil, coal, steam, etc., for two or more years should be analyzed. Heating fuel should be converted to BTU of heat content purchased per month. The demand and energy consumption records on the electric bills may be used directly. These records should be adjusted to reflect any known deviations from the "normal" year usage and weather data used in the calculated energy estimate and an adjusted month-by-month tabulation of purchased fuel BTU and electric KW and KWH should be developed.

The adjusted purchased energy tabulation should then be compared with the calculated energy budget estimate to identify substantive differences. Where deviations are significant, the budget estimate assumptions should be reviewed. If the budgeted values are deemed realistic, then the source of excessive energy consumption should be identified and an evaluation should be made of the cost/benefit relationship to improve the condition. Analysis of the quantity of energy used for each function will reveal the areas in which remedial effort may produce significant results. Adjustment of performance levels of the various building services or other changes that reduce design loads and modify operating characteristics may be analyzed for impact on costs and energy consumption. Simulation of the effects of proposed modifications can be individually considered to optimize effort and expense.

Suggested Maxi-Audit Procedure

Actual audits may deviate from this procedure when the following suggested criteria are not appropriate.

A. Calculate design heating and cooling loads for the building as constructed and used.
   1) Compare construction drawings to existing conditions to identify any deviations, such as: Window shading devices, infiltration characteristics of windows and doors, quality of thermal insulation, illumination devices installed and used, appliances and process equipment in use, substantial reassignment of space functions, etc.
   2) Establish operating techniques that are currently employed: Temperature and humidity conditions maintained, ventilation rate used, operating capacity and power requirements of fans, pumps, compressors, etc.
   3) Based on drawings and observations, calculate maximum heating load at winter design conditions and summarize sub-totals:
      a) BTU per hour conduction loss with no solar or internal heat gains.
      b) Outdoor air infiltrated, CFM when building ventilation equipment is off.
      c) Outdoor air introduced and exhausted, CFM when ventilation equipment is ON.
   4) Based on drawings and observations, calculate maximum cooling load at summer design conditions and summarize sub-totals:
      a) BTU per hour conduction gain at simultaneous peak time.
      b) BTU per hour solar heat gain at peak condition for each of cardinal compass points and for horizontal surfaces.
      c) Outdoor air introduced and exhausted, CFM when ventilation equipment is on in the cooling mode.
      d) BTU per hour of heat gained in the building from illumination devices.
      e) BTU per hour of heat gained in the building from appliances and processes.
      f) BTU per hour of heat gained from building occupants.
      g) BTU per hour of heat gained from temperature control system and HVAC components.
   5) Based on drawings and observations, calculate normal electrical energy used, KW per hour, occupied and unoccupied modes, *by heating and air conditioning distribution apparatus*.
   6) Based on drawings and observations, calculate normal electrical energy used, KW, or heat energy used, BTU per hour, occupied and unoccupied modes, by processes and appliances that are not included in "4" above. DO NOT include energy requirements of fuel conversion process or refrigeration for air conditioning in this summary.
      a) Building transportation, elevators, escalators, conveyors, etc.
      b) Domestic water pumps, sewage and sump pumps, drinking water coolers.
      c) Food refrigeration and cooking.
      d) Domestic water heating and laundry operations.
      e) Process air compressors.
      f) Boiler accessories, feed water systems, fuel pumps.
      g) Office and production machinery.
      h) Miscellaneous.

B. Calculate monthly energy load and annual totals for the *building heating, ventilation and cooling* requirements during normal use and weather. (Energy Output)
   1) Determine occupancy levels and durations for major building areas.
   2) Establish performance requirements of automatic temperature control system and components and identify impact of control sequence on refrigeration and heating loads.
   3) Determine programs of start-stop of apparatus, heat-cool changeover criteria, winter unoccupied mode set back temperature, utilization of outdoor air for non-refrigerated cooling, exhaust air equipment operating schedule.
   4) Establish a model weather year, including local normal outdoor temperature and humidity experience for each month and characteristic local interference with available sunlight because of cloud cover or other atmospheric conditions. Weather experience should be indexed to the usual occupancy conditions of the building so that weather incidents that occur when the building is unoccupied are separated from the weather that is coincident with building occupancy.
   5) Based on the data assembled, calculate normal monthly totals of energy required to serve the heating, cooling and ventilation loads established and tabulate in sufficient detail to allow analysis. The calculation must include a simultaneous determination of heat losses and gains for each weather incidence and with appropriate considerations of applicability of the gains to the losses. In addition, the calculations must account for the automatic and manual control of the heating and cooling apparatus so as to reflect the response of the energy using equipment to changing requirements of weather and occupancy.

C. Calculate monthly consumption of energy and annual totals required by the *building systems*. (Energy Input)
   1) Tabulate fuel input (or electric energy) to serve heating, domestic hot water and process loads, including suitable provisions for conversion efficiency at varying loads.

2) Tabulate electric energy input for refrigeration system components required to serve the air conditioning loads.

3) Tabulate fuel input to serve heat actuated refrigeration equipment required to serve the air conditioning load.

4) Tabulate electric energy input separately for interior illumination, air handling equipment, fluid handling equipment, boiler and heating accessories, and other electrical loads.

D. Compare and adjust calculated energy input totals with records of fuel and electricity purchase records for a two-year span.

1) Adjust records of monthly fuel and utility bills to reflect (a) Calendar months in lieu of billing periods, and (b) Aberrations in experience because of deviations from normal occupancy and weather.

2) Compare calculated energy input with adjusted records of fuel and utility purchases. Where calculated energy is greater than adjusted purchases, review the calculation input information and adjust the calculations to reflect actual usage. This revised tabulation is the Energy Budget. Where purchased energy exceeds the Budget, there is opportunity for increased efficiency of utilization.

E. *Recommend Energy Conservation Measures* (Separate into standard groupings)

1) Analyze the Maximum Heating and Cooling Loads to determine opportunities for load reduction by modification of the building envelope thermal effectiveness and for changes in ventilation rate and boiler modifications. The probable results of such changes can be measured or estimated by recalculating the annual energy use and determining the effect on energy purchases.

2) Analyze the energy used by air handling and fluid handling equipment. If substantial changes are made in Heating and Cooling Loads, it may be possible to make beneficial revisions to the apparatus and use of these sub-system components to further reduce energy consumption.

3) Analyze the building automation systems and determine the effects of changes to start-stop programming, night setback, temperature control sequences and set points. Changes in occupancy schedules should be considered in assessing possible reductions of hours of equipment operation.

4) Review budgeted allowances for Processes and Appliances and make detailed analysis where the quantities justify the effort.

5) Review budget allowances for illumination energy and analyze apparatus, performance levels and operational techniques to reduce energy consumption. If substantial changes are made in reducing illumination energy use, the Heating and Cooling Loads will be affected and there may be beneficial revisions in other energy uses.

6) Analyze budget allowances for energy conversion apparatus, i.e. refrigeration system, fuel conversion equipment, etc., and calculate annual efficiencies. Considering probable changes in building loads, operation schedules, temperature control system, etc., estimate possible impacts on energy conversion efficiencies.

7) Recalculate the annual energy uses for the project as it would be modified by energy conservation measures selected as most probable. This evaluation will provide a reasonable basis for predicting effects of proposed changes on energy purchases.

8) Identify the expected reduction in energy use for each proposed change in the program so that the performance can be measured and the responsibility for continued surveillance can be allocated.

9) Develop suitable monitoring procedures to record the performance of modified equipment or procedures. Recommend instrumentation such as:

   a) Elapsed time meters to record hours of operation of prime movers.

   b) Electric watthour meters to record usage of electric energy for specific operations or departments.

   c) Fuel meters to record consumption of fuel for specific operational purposes.

   d) BTU meters, steam flow meters or condensate meters to identify heat input or output of processes or building environmental apparatus.

   e) Recording thermometers to verify performance of critical automatic temperature controls.

   f) Recording ammeters to monitor relative load changes in electric prime movers and power distribution feeders.

10) Develop reporting procedures and summaries to monitor the operating and maintenance personnel execution of energy conservation program elements. Daily, weekly and monthly logs of equipment use, meter readings and performance evaluations should be summarized and reported to operating personnel. Continued reference to performance goals and actual achievement is necessary to sustain interest and reward successful effort and skill at the level at which operating decisions are actually made.

11) Prepare comparative statements of energy use semi-annually to show the actual purchases of electricity and fuel compared to the Energy Budget and the Adjusted Record of Energy purchased in the past. Graphic presentations may provide a continuing synopsis of the effects of energy conservation programs.

PUBLIC SCHOOLS ENERGY CONSERVATION SERVICE*

*PSECS

A PROGRAM
TO ASSIST
SCHOOL DISTRICTS
IN UNDERTAKING
EFFECTIVE PLANS
TO CONSERVE ENERGY
AND MONEY

ELEMENTARY AND
SECONDARY SCHOOL PROGRAM

EDUCATIONAL FACILITIES
LABORATORIES INC.

Educational Facilities Laboratories, Inc., in conjunction with the Federal Energy Administration, has developed an inexpensive computer-based technical service designed to assist school districts in the development of effective energy conservation programs for their physical plants.

The Public Schools Energy Conservation Service (PSECS), is a product of two and one half years of research, development and testing, involving more than 320 school districts and 2100 elementary and secondary schools. By taking advantage of recent advances in engineering and computer technologies, PSECS is able to establish energy use guidelines for electricity and fuel for most school plants. These guidelines take into consideration such factors as climate, pattern of use, and special physical characteristics of the facility. By comparing the actual use with the guideline, the plant's potential for both energy and dollar savings is determined.

The Service has been designed to work interactively with school and district staff members, and provides modification information on two levels. On level one, the operating level, the PSECS Self-Audit Program provides suggestions for bringing the plant down to guideline levels with little or very modest expenditures. Experience to date indicates that savings of 25 to 30 per cent can usually be achieved if the PSECS operating suggestions are followed.

At level two, capital modifications requiring larger investments are analyzed, using simple life cycle cost procedures to obtain a selection of cost effective modifications specific to each school. This computer analysis is intended to indicate those modifications that have sufficient merit to justify the employment of design professionals to carry out a more detailed analysis.

The Public School Energy Conservation Service is designed to help school districts help themselves. PSECS can provide your school district with information which, if seriously and appropriately used, will result in major energy and cost savings.

EDUCATIONAL FACILITIES LABORATORIES INC.
3000 Sand Hill Road
Building 1, Suite 120
Menlo Park, California 94025

PHASE I
OPERATIONS AUDIT

–Upon receipt of the attached mailer, EFL will send you the appropriate forms.

–Complete forms and return them to EFL together with $20.00 for each elementary school and $35.00 for each secondary school.

–Payment must accompany data forms (no purchase orders please.)

–EFL will process the data and provide you with:

1. Summary Report on Energy Consumption
A district wide report on the actual and guideline energy use of each school and the savings possible if the schools were operating at the same efficiency as the guideline model.

2. Self Help Audit
A report on the actual fuel use of each school, the guideline fuel use for that school and the estimated savings if the school is operated at the same efficiency as the guideline model.

A manual for identifying the operations of the school which deviate from the guideline conditions.

3. Order form for the Capital Audit

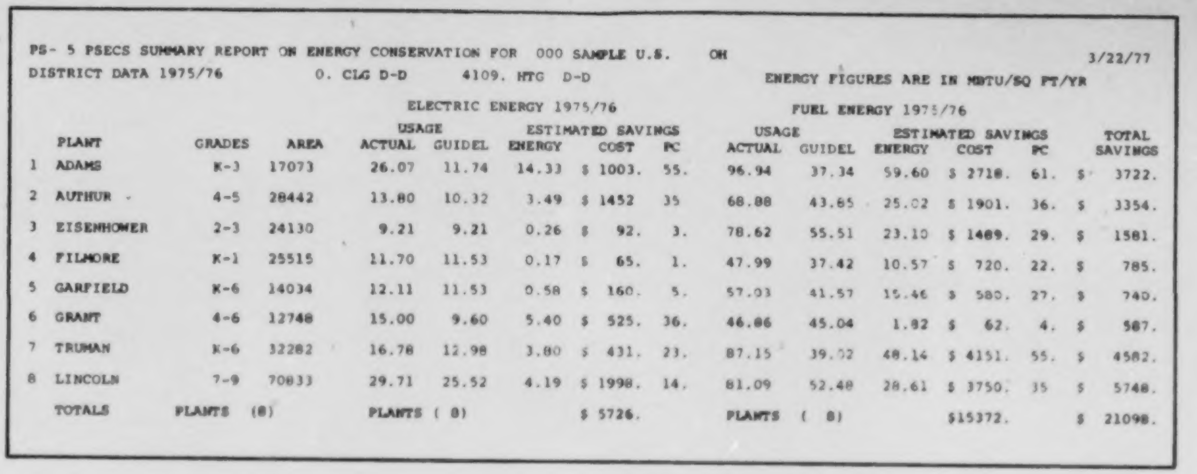
PHASE II
CAPITAL AUDIT

–Upon receipt of the Capital Audit Order Form, EFL will send you the Capital Audit Questionnaire.

–Complete the Capital Audit Questionnaire and return it to EFL with $10.00 for each elementary school and $15.00 for each secondary school.

–EFL will process the data and provide you with:

1. Capital Modifications Survey
A report that identifies Capital Modifications and their Cost/Benefits.



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PS- 5 PSECS SUMMARY REPORT ON ENERGY CONSERVATION FOR  000 SAMPLE U.S.    OH                                      3/22/77
DISTRICT DATA 1975/76          0. CLG D-D       4109. HTG  D-D                     ENERGY FIGURES ARE IN MBTU/SQ FT/YR

                                         ELECTRIC ENERGY 1975/76                     FUEL ENERGY 1975/76
                                       USAGE        ESTIMATED SAVINGS           USAGE          ESTIMATED SAVINGS          TOTAL
   PLANT          GRADES   AREA    ACTUAL  GUIDEL  ENERGY    COST   PC     ACTUAL  GUIDEL  ENERGY    COST    PC        SAVINGS
1  ADAMS           K-3    17073    26.07   11.74   14.33  $ 1003.  55.     96.94   37.34   59.60  $ 2718.  61.   $     3722.
2  AUTHUR  -       4-5    28442    13.80   10.32    3.49  $ 1452   35      68.88   43.85   25.02  $ 1901.  36.   $     3354.
3  EISENHOWER      2-3    24130     9.21    9.21    0.26  $   92.   3.     78.62   55.51   23.10  $ 1489.  29.   $     1581.
4  FILMORE         K-1    25515    11.70   11.53    0.17  $   65.   1.     47.99   37.42   10.57  $  720.  22.   $      785.
5  GARFIELD        K-6    14034    12.11   11.53    0.58  $  160.   5.     57.03   41.57   15.46  $  580.  27.   $      740.
6  GRANT           4-6    12748    15.00    9.60    5.40  $  525.  36.     46.86   45.04    1.82  $   62.   4.   $      587.
7  TRUMAN          K-6    32282    16.78   12.98    3.80  $  431.  23.     87.15   39.02   48.14  $ 4151.  55.   $     4582.
8  LINCOLN         7-9    70833    29.71   25.52    4.19  $ 1998.  14.     81.09   52.48   28.61  $ 3750.  35    $     5748.
   TOTALS        PLANTS  (8)      PLANTS ( 8)             $ 5726.          PLANTS  ( 8)           $15372.        $    21098.
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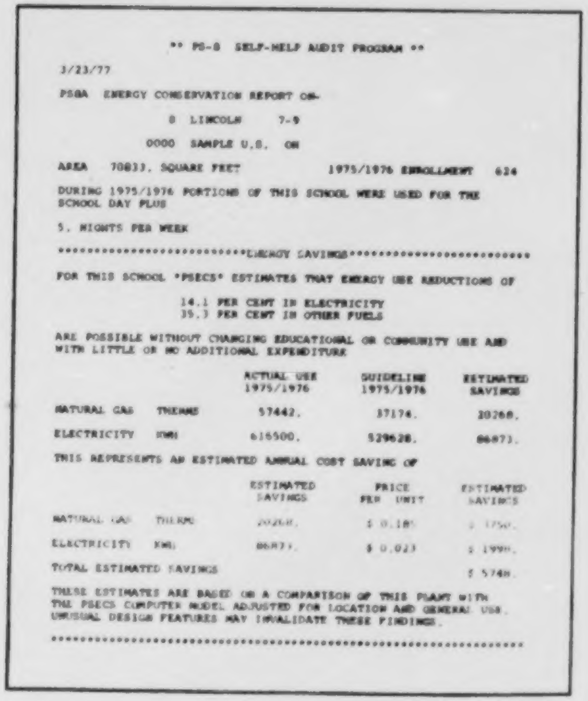

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                 ** PS-8  SELF-HELP AUDIT PROGRAM **

3/23/77

PS8A  ENERGY CONSERVATION REPORT ON-

                8  LINCOLN      7-9

             0000  SAMPLE U.S.  OH

AREA   70833. SQUARE FEET                 1975/1976 ENROLLMENT   624

DURING 1975/1976 PORTIONS OF THIS SCHOOL WERE USED FOR THE
SCHOOL DAY PLUS

5. NIGHTS PER WEEK

**************************ENERGY SAVINGS**************************

FOR THIS SCHOOL *PSECS* ESTIMATES THAT ENERGY USE REDUCTIONS OF

                  14.1 PER CENT IN ELECTRICITY
                  35.3 PER CENT IN OTHER FUELS

ARE POSSIBLE WITHOUT CHANGING EDUCATIONAL OR COMMUNITY USE AND
WITH LITTLE OR NO ADDITIONAL EXPENDITURE

                          ACTUAL USE      GUIDELINE      ESTIMATED
                          1975/1976       1975/1976       SAVINGS

NATURAL GAS   THERMS       57442.          37174.         20268.

ELECTRICITY   KWH         616500.         529628.         86873.

THIS REPRESENTS AN ESTIMATED ANNUAL COST SAVING OF

                          ESTIMATED        PRICE         ESTIMATED
                           SAVINGS       PER  UNIT        SAVINGS

NATURAL GAS   THERMS       20268.         $ 0.185        $ 3750.

ELECTRICITY   KWH          86873.         $ 0.023        $ 1998.

TOTAL ESTIMATED SAVINGS                                   $ 5748.

THESE ESTIMATES ARE BASED ON A COMPARISON OF THIS PLANT WITH
THE PSECS COMPUTER MODEL ADJUSTED FOR LOCATION AND GENERAL USE.
UNUSUAL DESIGN FEATURES MAY INVALIDATE THESE FINDINGS.

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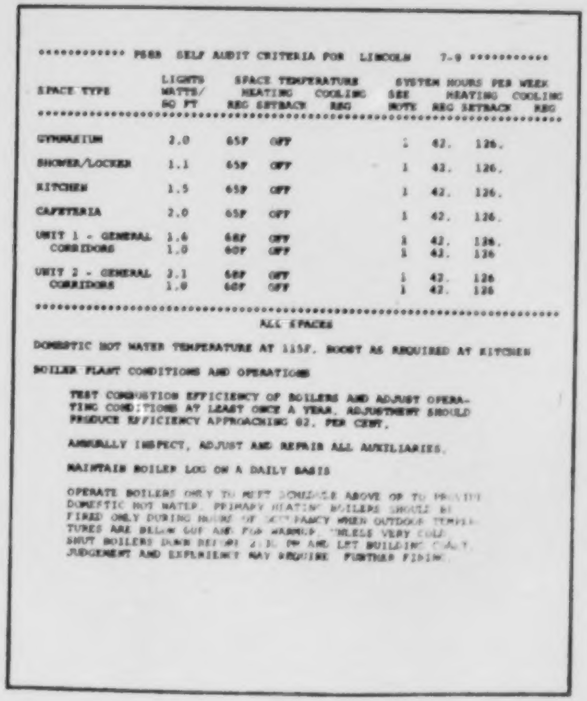

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************ PS8B  SELF AUDIT CRITERIA FOR  LINCOLN     7-9 ***********

                 LIGHTS     SPACE TEMPERATURE      SYSTEM HOURS PER WEEK
SPACE TYPE       WATTS/      HEATING   COOLING    SEE     HEATING   COOLING
                 SQ FT     REG SETBACK   REG      NOTE  REG SETBACK   REG
**************************************************************************

GYMNASIUM         2.0      65F   OFF               1    42.   126.

SHOWER/LOCKER     1.1      65F   OFF               1    42.   126.

KITCHEN           1.5      65F   OFF               1    42.   126.

CAFETERIA         2.0      65F   OFF               1    42.   126.

UNIT 1 - GENERAL  1.6      68F   OFF               1    42.   126.
  CORRIDORS       1.0      60F   OFF               1    42.   126

UNIT 2 - GENERAL  2.1      68F   OFF               1    42.   126
  CORRIDORS       1.0      60F   OFF               1    42.   126
**************************************************************************
                              ALL SPACES

DOMESTIC HOT WATER TEMPERATURE AT 115F. BOOST AS REQUIRED AT KITCHEN

BOILER PLANT CONDITIONS AND OPERATIONS

    TEST COMBUSTION EFFICIENCY OF BOILERS AND ADJUST OPERA-
    TING CONDITIONS AT LEAST ONCE A YEAR. ADJUSTMENT SHOULD
    PRODUCE EFFICIENCY APPROACHING 82. PER CENT.

    ANNUALLY INSPECT, ADJUST AND REPAIR ALL AUXILIARIES.

    MAINTAIN BOILER LOG ON A DAILY BASIS

    OPERATE BOILERS ONLY TO MEET SCHEDULE ABOVE OR TO PROVIDE
    DOMESTIC HOT WATER. PRIMARY HEATING BOILERS SHOULD BE
    FIRED ONLY DURING HOURS OF OCCUPANCY WHEN OUTDOOR TEMPERA-
    TURES ARE BELOW 60F AND FOR WARMUP. UNLESS VERY COLD
    SHUT BOILERS DOWN BEFORE [illegible] PM AND LET BUILDING COAST.
    JUDGEMENT AND EXPERIENCE MAY REQUIRE FURTHER FIRING.
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FROM: THE NEW JERSEY SUPPLEMENTAL ENERGY CONSERVATION PLAN

A grant application submitted to the Federal Energy Administration under the authority of Part B, Title IV of the Energy Conservation and Production Act, P.L. 94-385, and the Federal Energy Administration Guidelines as described in CFR Title 10 Part 420.100-420.109, July 1977.

PUBLIC SCHOOL ENERGY CONSERVATION SERVICE

Description:

New Jersey's 611 school districts are responsible for 2,464 buildings across the state. Preliminary energy audits of schools in two districts (Neptune Township in Monmouth County and West Milford Township in Passaic County) have, not surprisingly, found that existing school buildings can be made much more energy efficient at great savings to the school district.

For example, by making minor changes in operating and maintenance procedures, the West Milford school district reduced its energy consumption by the equivalent of 3,100 barrels of oil and has saved the taxpayers over $100,000 per year in reduced fuel bills. Audits of the Neptune and Hackensack school districts by the New Jersey Institute of Technology are now being analyzed.

In order to assist local school boards to identify areas of energy waste, the Departments of Energy and Education will encourage the school boards to participate in the Public School Energy Conservation System (PSECS), developed by the Educational Facilities Labs, Inc. (EFL), under an FEA grant. PSECS is a computer model which compares actual energy consumption in a school against a theoretical model of that school operating at peak efficiency. A second phase of the computer printout will also analyze the cost effectiveness of selected energy conservation improvements such as insulation. The only cost to the school district will be a fee of $30-$50 per school to cover the costs of the computer analysis.

Because EFL has not had time to fully monitor the impact of the PSECS model, we propose that Phase I of the supplemental grant evaluate the relative merits of the PSECS evaluation versus an energy audit undertaken by a professional engineer. This will be accomplished by running the Neptune and Hackensack school districts through the PSECS program. The comparison of results with the NJIT audit will enable us to determine the most cost effective use of the PSECS program and on-site audit, i.e., PSECS followed by a full audit, PSECS alone, or an on-site audit alone. This will be done in time to implement a statewide program in the second year of the grant. Assuming that we will use the PSECS model statewide, the State of New Jersey will purchase the computer program from EFL, and use the Engineering and Development Data Center in the New Jersey Department of Transportation to process the computer questionnaire.

Coordination:

Planning and implementation of this program will be jointly carried out by the Department of Energy, Division of Planning and Conservation; the Department of Education, Bureau of Facility Planning; and the Department of Transportation. The Department of Energy will be responsible for the development of the program, while the Department of Education will work directly with the school districts to encourage their participation and to provide assistance where required. The DOT will provide its computer capability.

Estimated Energy Savings:

Because this office has no data on energy use by schools in the state, it is impossible to determine with certainty how much can be saved through the implementation of this program. It is not clear that the West Milford school district, where data is available, is typical for the state. If we assume that they are, however, we can project a savings of 4.4×10^{12} Btu with no capital investment.

The West Milford school district comprises 9 buildings; 7 elementary schools, 1 middle school, and 1 high school. The buildings range from 10-35 years old, with the average slightly newer than the statewide average age of school buildings.

Through a concerted effort to improve maintenance and operation of the school, West Milford conserved approximately 3,100 barrels of oil in the 9 buildings. This was an average of 344 barrels per school building.

There are 2,464 school buildings in the state. If we assume that each school building can conserve at least 334 barrels, then we arrive at the total as follows:

$$2{,}464 \text{ schools} \times 344 \frac{\text{bbl}}{\text{school}} \times 42 \frac{\text{gallons}}{\text{barrel}} \times 125{,}000 \frac{\text{Btu}}{\text{gallon}} =$$

$$4.4 \times 10^{12} \text{ Btu/yr}$$

The dollar savings to the West Milford school district was $100,000 or one-sixth of the district's total energy costs. Averaged out to each school building, the savings were worth $11,000 per building. Multiplied by 2,464 schools, the statewide dollar savings to the taxpayers would equal $27,104,000 with no capital investment required.

Verification:

The PSECS program can be adapted to provide a continuing energy data collection system for the schools, to monitor not only direct energy costs but also the impacts of various energy conservation measures.

Environmental Residuals:

There will be no adverse environmental impact of this program, since it will reduce consumption of fossil fuels by schools.

ENERGY ASSESSMENTS OF SCHOOLS

	P.S.E.C.S.	MINIAUDIT	MAXIAUDIT
BASIC DESCRIPTION	A computer program that can simulate energy needs for real-life school buildings and their functions designed to assist school districts in undertaking effective plans to conserve energy and money.	Walk-through, cursory, on-site inspections of buildings analyzing structures, HVAC systems, operational practices and other factors relating to energy consumption, leading to measures that could be done quickly and with little or no cost.	The most comprehensive examination of energy use patterns in a school building, and the most complete identification of economical conservation measures. A thorough study of the physcial plant, its operating systems, use patterns and historic energy consumption data to determine the potential for energy savings.
DATA NEEDED FOR PROGRAM	The school supplies P.S.E.C.S. with basic building data such as size of building, student enrollment, program, fuel and electricity consumption and weather data.	Operational and maintenance records, building statistics (age, square feet, etc.) condition of building, windows, doorways, etc.	Accurate information on many aspects of building operation and energy use including: weather and climate data; quantities of energy used; building use patterns; construction details of the building; its HVAC systems, instrumentation and functional accuracy; and significant details in ways building systems are operated by students, staff and operating engineers. Information should be verified before calculations are made.
PERSONNEL INVOLVED	School administrator, maintenance supervisor — NO outside help necessary.	— Professional HVAC systems engineer — Gas and/or electric utility technical representative or fuel company representative — Chief operating engineer for the building — One or more building administrators.	— Professional engineer/architect.
TIME	30-60 minutes per building if records up-to-date.	Building walk-through —1-2 hours. Writing report — 1 day.	Varies with condition of building, depth of study, condition of records, etc.
METHODOLOGY	Record-keeping data sent by district to computer base. Information returned by mail.	Physical walk-through inspection of building with special attention to structure, HVAC system, operational practices, and maintenance procedures.	Thorough analysis of current energy use in the building.
INFORMATION OR FEEDBACK TO SCHOOL	Realistic estimate of energy needs of the school by comparing its consumption with the guideline model. School administrators can learn where they can save money by reading the report produced by computer simulation.	Energy conservation measures that are, for the most part, quickly and easily implemented by operating personnel. Has proven to be a useful tool for implementing a variety of no-cost and low-cost conservation measures. Can indicate the need for a more extensive Maxiaudit.	— Low-cost to no-cost operation and maintenance procedures. — Major energy conservation retrofit measures. — Computation of potential cost savings.
SPECIAL BENEFITS OR PARTICULAR CHARACTERSTICS	Provides immediate awareness of potential for energy-saving at low cost.	Results in recommendations that are specific to a given building and its operation rather than being generalized for a type of building.	— Opportunity to make decisions based on best possible projections of energy savings and their dollar impact. — Suggestions in operations and maintenance area can be implemented almost immediately. — Provides energy information at a level of detail obtainable in no other way; often returns cost in surprisingly short time.
COST	$25 to $35 per building.	Usually less than $200 per building.	$3,000 to $10,000 per building.

PUBLIC SCHOOLS
ENERGY CONSERVATION
MEASURES

Report Number 2

CENTRAL ELEMENTARY SCHOOL
Glen Rock, New Jersey

FLACK & KURTZ

Prepared For The

FEDERAL ENERGY ADMINISTRATION

By

AMERICAN ASSOCIATION OF SCHOOL ADMINISTRATORS

Contract CR - 04 - 60711 - 00

The views and conclusions contained in the document are those of the authors, and should not be interpreted necessarily representing the official policies of the U.S. Government.

January 24, 1977

PREFACE

The plight of the public schools in the face of rapidly depleting energy resources and escalating energy costs has been a matter of concern to the Federal Energy Administration (FEA) and other government agencies, as well as organizations such as the American Association of School Administrators (AASA). Reports have been published outlining the problems of energy usage in public schools, its impact on school budgets and possible ways to reduce energy consumption in existing buildings. More substantive information is needed to assist school administrators and federal energy/education decision makers in identifying specific cost-effective remedies to existing school buildings.

The schools of America consume eleven percent of the space heating/cooling energy. Over fifty percent of the schools now in use were built in the post World War II "baby boom" when first cost was far more important than energy efficient buildings. A recent FEA report revealed that energy costs to the schools increased 48.3% in a two year period (1972-73 to 1974-75). The continued escalation of energy costs coupled with energy inefficient buildings and exacerbated by general inflation has created a critical problem for the schools.

Since it has been estimated that nearly fifty percent of the space heating/cooling energy consumed by the schools is wasted, it is also a grave problem for our nation. The 1975 Congressional report on energy noted that the most economical, accessible way to "gain" fuel reserves is to reduce consumption.

School people want to reduce this waste and unnecessary expenditure. The development and dissemination of information which will enable school administrators to identify and analyze energy conserving opportunities in existing buildings is badly needed. It is critical that school people have access to the options available to meet identified energy needs, their respective costs, and the associated energy savings.

In order to provide such guidelines and to demonstrate the desirability of retrofitting existing school buildings, AASA initiated the project Saving Schoolhouse Energy. The emphasis in this study was placed on the cost effectiveness of capital modifications utilizing "off-the-shelf-hardware." The project was designed in five phases: (1) select ten elementary school buildings and analyze their energy conserving opportunities; (2) undertake needed architectural or engineering design work; (3) install or construct recommended modifications; (4) monitor and record post-modification energy use; and (5) disseminate the findings.

Phase 1, selection of the ten demonstration sites and an engineering analysis of energy conserving opportunities for each, was funded by the Federal Energy Administration.[1] This report for Central Elementary School in Glen Rock, New Jersey, represents the culmination of Phase 1 for one of these sites and is one of ten (10) such reports. Other sites in the study were Harold C. Scott Elementary School, Warwick, Rhode Island; Samuel Everitt Elementary School, Langhorne, Pennsylvania; Hindman Elementary School, Hindman, Kentucky; Fairmoor Elementary School, Columbus, Ohio; P. F. Brown Elementary School, Lubbock, Texas; Eastridge Elementary School, Lincoln, Nebraska; Garfield Elementary School, Sioux Falls, South Dakota; Plover Whiting Elementary School, Stevens Point, Wisconsin; Washington Elementary School, Kennewick, Washington.

Under this first phase, ten elementary school buildings were selected, one from each federal region, with the exception of Region 9. Because the criteria established for selection could not be met by any of the applicants or any of the other Region 9 schools which AASA identified through a cooperative search with the respective state departments of education, this region was omitted and, instead, a second school was selected in Region 5 to represent the northern portion of that area. Criteria used for selection of the demonstration schools included: type of structure, predictably consistent usage patterns after modifications, building longevity, building size, student enrollment, available energy consumption data, and expected energy savings as predicted through the use of the Public School Energy Conservation Service (PSECS)[2] computer program. It is important to note that every effort was made to find typical schools, not "bad examples;" for experience has shown "energy and dollar saving retrofit opportunities exist at even the most well maintained facilities."[3]

After the sites were selected, a thorough and comprehensive investigation of energy conserving opportunities for each building ensued. In this study, the PSECS material, the TRACE[4] or Ross Meriwether[5] computer programs, as-built drawings, and on-site surveys were the basis for the engineering judgment as to feasible energy conserving measures to be recommended. Such recommendations considered: (a) changes in HVAC or lighting systems or equipment, including controls; (b) modifications in operations; (c) structural changes; (d) estimated cost(s) of implementation; and (e) estimated energy savings that are expected to accrue. In addition to their engineering feasibility, the recommendations also considered the possibility of significant cost benefit, educational desirability, and environmental acceptability.

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[1] Federal Energy Administration Contract CR-04-60711-00, April 20, 1976.

[2] PSECS was developed by the Educational Facilities Laboratories, Inc. under a Federal Energy Administration Contract.

[3] Identifying Retrofit Projects for Federal Buildings, p. 2.

[4] TRACE computer program 200 developed by Trane Company.

[5] Meriwether ERE computer program.

MANAGEMENT SUMMARY

Central Elementary School
Glen Rock, New Jersey

A thorough and comprehensive engineering analysis of ten representative elementary schools across the nation was undertaken to identify cost-effective energy conserving opportunities. The reports of these studies are designed to provide school administrators, engineers, architects, and associated technical personnel with indicators of potential energy savers in similar buildings. The following information is a summary of one of these ten reports.

Central is representative of a 1920's building with a pre-World War II addition of similar construction and a 1950's addition located in a 3,000-6,000 degree day climate.

BUILDING CHARACTERISTICS

Size:

45,384 sq.ft.
18 classrooms, library, multipurpose area, and administration center. Central also has an auditorium and the district administration offices.

Occupancy:

300 students, K-6, 30 staff (including district administration personnel).
School day: 9:00 a.m. to 3:00 p.m.; staff and administration 8:00 a.m. to 6:00 p.m.
School year: early September to late June; district administration 15 adults 8:00 a.m. to 6:00 p.m. except August.

Construction:

Original structure was built in 1925 and has 33,000 sq.ft. It has two levels.
Walls: 4" face brick, 2" air, 8" concrete block with plaster finish with 35% double hung single pane glass.
Roof: Built up roofing over plywood deck, interior ceiling drop with plaster board or acoustical tile; no insulation.
1st addition (1939) is similar structure, but a single level of 3,840 sq.ft.
2nd addition (1958) is single story with 8,544 sq.ft.
Walls: 4" face brick, 8" concrete, no insulation with 60% single pane casement glass.
Roof: Built up over wood sheathing with air space; 2" insulation and acoustical tile over steelrock.

Heating, ventilating, and air conditioning:

Unit ventilators and radiators in classrooms and auditorium. One pump for original structure and 1st addition; 2nd pump for 1958 addition controlled manually.
Heated by (2) 1925 oil-fired low steam boilers (converted from coal). (2) hot water converters (1957) changed from steam to hot water.
Cooled by (9) window air conditioners in child study area and administrative areas.

Illumination:

Fluorescent in all but gym which has (24) 300 watt mercury vapor lamps; typical illumination 1.7 watts/sq.ft. In dropped celing area has 2.85 watts/sq.ft. and 1958 addition has 1.9 watts/sq.ft.
Exterior security: 1950 watts controlled by light sensor and time clock.

Energy consumption and cost:

	Oil				Electricity	
Year	Gals.	Gals/sq.ft.	DD	Gal/DD	KWH	KWH/sq.ft.
1972-73	42,682	.94	4,707	9.07	--	--
1973-74	40,324	.89	4,452	9.06	164,000	3.6
1974-75	45,538	1.00	4,594	9.9	153,240	3.4
	Cost: $0.34/gal				$0.019/KWH	

ENERGY CONSERVING RECOMMENDATIONS

The following recommendations are made for an existing building with the characteristics described above. They offer guidelines for analyzing buildings with similar characteristics; however, suggested energy conserving opportunities (ECOs) must be weighed in terms of the fuel used, its cost and associated savings as well as capital expenditure considerations. While it is not the primary intent of this report to address new construction concerns, the findings do have implications for such work.

A routine inspection of the entire control system including recalibration of thermostats, rebalancing of dampers should be undertaken irrespective of following recommendations. It is assumed to have preceded the following recommendations and associated calculations.

The following energy conserving opportunities appear to be cost-effective and are recommended for Central:

- Reduce outside air
  --500 cfm down to 175 cfm (175 cfm complies with State directive)
- Replace boiler with modular hot water boilers
- Replace thermostat settings
  --from 70° F to 68° F
- Install motor operated damper to close louvers and roof ventilators in auditorium
- Install roof insulation
  --blanket type in existing 3' airspace between deck and ceiling
- Reduce infiltration
  --weather stripping windows and doors
  --automatic dampers at roof ventilators

SUMMARY TABLE: Recommended Energy Conserving Measures at Central Elementary School, Glen Rock, New Jersey

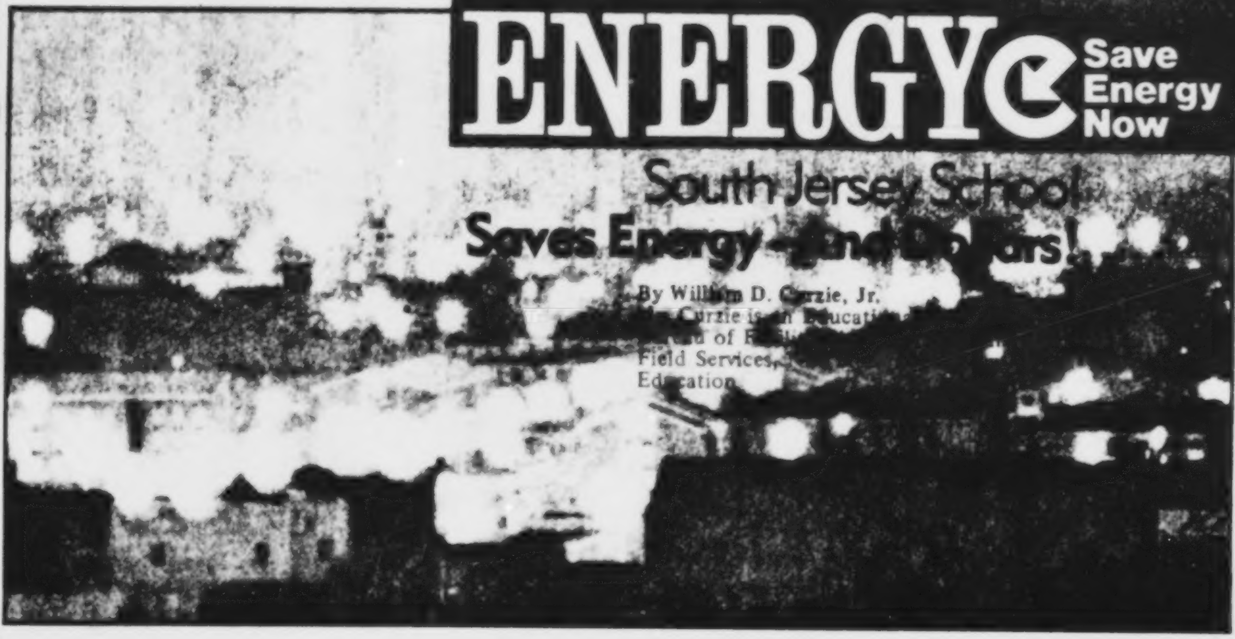
ECOs	Estimated Cost	Recovery Rate
1. Reduce outside air	$ 5,000	5 yrs.
2. Replace boilers	20,000	6 yrs.
3. Reduce thermostate settings	0	immediate
4. Install motor operated damper	1,350	2 yrs.
5. Install roof insulation	7,200	7 yrs.
6. Reduce infiltration	6,000	6 yrs.
ALL RECOMMENDATIONS	$39,550	6 yrs.

OTHER CONSIDERATIONS

The above recommendations and calculations were based on $0.34/gal escalated at 10% per annum with [illegible].9% interest. As the cost of fuel exceeds this rate, other ECOs may become cost-effective and should be reviewed. Any reconsideration should not view adjusted energy and dollar savings in isolation; materials, labor, interest rates, etc. must also be assessed. The following ECO may warrant future review: institute warm up cycle with dampers closed.

Finally, it should be noted that in a free market availability is reflected in cost. However, fuels have not had such a history. As long as fuel costs and supply are in any way regulated, actual fuel availability may transcend the cost-effective characteristics of a modification.

ENERGY Save Energy Now



South Jersey School Saves Energy—and Dollars!

By William D. Curzie, Jr.
[illegible] Curzie is an Educatio[illegible]
[illegible] of [illegible]
Field Services, [illegible]
Education

Like Mark Twain's weather, when it comes to saving energy, it seems that "everybody talks about it, but nobody does anything about it".

Walter Quint, West Deptford High School Science Department Head, decided to do something about it. Not about the weather—about energy conservation; and he also interested his students in doing something.

Nearly four years ago, before the word "energy crisis" hit home at the gas pumps, Quint and his Science students decided that energy conservation is necessary if we are to extend our standard of living into the near future. They decided to educate others about this fact through a conservation of energy program in their South Jersey High School building.

Saving energy, they reasoned, becomes much more attractive to the administration when saving money is a result of conservation practices. The following list of recommendations was compiled by the High School Physics students, and implemented by the administration in early 1973:

Walter Quint, West Deptford High School Science Department Head and Coordinator of the School's efforts to conserve energy and dollars.

Recommendation #1.

Changes in the Main Office lighting practices:

a) Substitution of fluorescent in place of multiple incandescent ceiling lights (more efficient).
b) Installation of burglar alarm (eliminating night lighting).
c) Multi-switch control of ceiling lights, (only lights actually needed are put in use).

Energy Savings – 9,110 kwhrs per year
Dollar Savings – At 3.25¢ per kwhr to 1.4¢ per kwhr, depending on usage factors, the savings varied from $127. to $296. per year.[1]

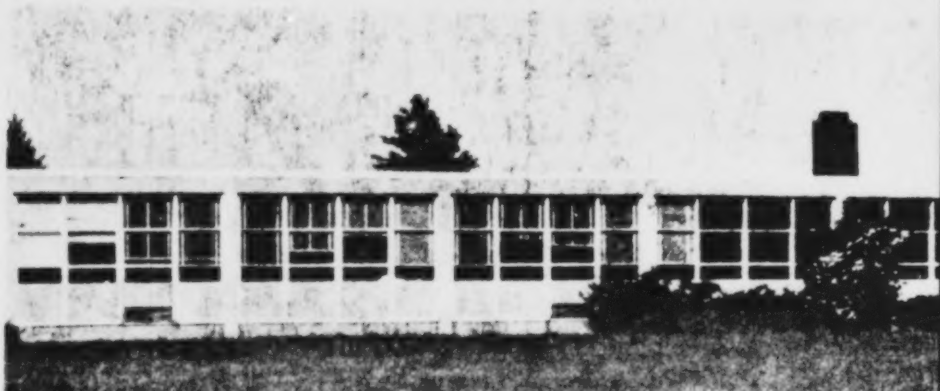
Recommendation #2

Lights out in the cafeteria, because they are not necessary during the day. (Natural light from windows has proven sufficient for the social activities taking place in that area.)

Energy Savings – 9,072 kwhrs per year
Dollar Savings – When completely off, $100. to $300. per year. Modification of amount used naturally reduces savings proportionately.

Recommendation #3

Modification of lighted Exit signs. As



This photo, taken after regular p.m. dismissal, reveals two energy saving aspects: 1.) open blinds indicate natural lighting was being used during class time. 2.) Darkened interiors prove students and teachers have acquired the habit of turning off lights when room becomes unoccupied.

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[1] *The price of 3.25¢ per killowatt hour was the standard price being charged.*

long as "readily visible", reduction in light is not a safety factor.

Energy Savings – 5,784 kwhrs per year.
Dollar Savings – $187.38 per year.

Recommendation #4

Custodians should keep lights out in areas not in use.

For example, many unoccupied storage rooms had been left with three hundred watt bulbs burning for long periods of time; turning these lights off when not needed, the students determined, would save about the same as for an average classroom.

Energy Savings – 5,184 kwhrs per year
Dollar Savings – $120. per year

Recommendation #5

Turn out lights in classrooms when not in use. The West Deptford students increased awareness of energy conservation techniques to the point where individuals soon established the habit of turning out lights when realizing the room was to be unoccupied.

Energy Savings – 5,184 kwhrs per year (based on one of six rooms per mod out of use.)
Dollar Savings – $120. per year

Recommendation #6

Corridor lighting should be reduced from two to only one ballast in each fixture.

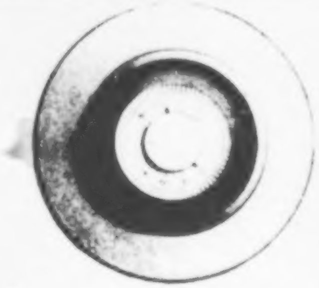
Energy Savings – 11,644 kwhrs per year
Dollar Savings – $351. per year

Totaling the above dollar savings, the students estimate that these six practices, with virtually no capital expenditures, but using only common sense conservation habits, save the West Deptford High School from $837. to $1,302.38 annually, and conserves over 40,000 kwhrs of vital energy. With the kwhr rate escalating to 5.6¢, the saving now can reach over $2,000. per year.

If each high school in New Jersey did like-wise, assuming West Deptford High School is an average-size high school; at approximately 450 such buildings, there would have been an accumulative saving of $376,650. to $575,900. per year. With our over 2,000 elementary schools included, the figures soar to over the million dollar figure, based on the 1973 rate – at the present rate, it now could be double these figures. (over $1 million for the high schools alone).

Such energy and dollar savings need not be confined to the school building. Walter Quint practiced at home what he taught in the classroom. Through similar conservation practices in his own home, without causing any real personal discomfort, according to Quint, in over a year's time, he reduced his electrical bill from 592 kwhr to 292 kwhr! – or by more than one-half! Ironically, he had to pay within $5.00 of the old bill, due to the rapid rate increase. On the other hand, had he not reduced his usage, he would have been in the same situation as most – it would have cost him *TWICE* as much for the same amount of electricity.

Physics classes use no new paper. Tablets are made from scrap paper, as another effort at conserving energy.



Thermostats keep temperatures at comfortable levels, but vary according to activity area. Such factors as the amount of body heat in a relatively crowded classroom, or the amount of time spent in a corridor should be considered in heating controls.

Empty Rooms Love Darkness
DON'T BE FUEL–ISH!

These visual aids remind building occupants of the on-going conservation efforts which are becoming part of their daily routine.

[*F.E.A.* (*Federal Energy Administration*) *sends free energy crisis light switch covers upon request.*]

West Deptford High School is one example of the results which can be achieved through individual efforts properly channeled and directed. Other schools can achieve similar goals. Those considering the undertaking should note that none of the conservation measures undertaken at West Deptford have caused any noticeable difference in the school routine; avoiding wasteful practices and using common sense, the core of their program causes no hardships or discomforts – on the contrary, the overall effect is actually healthful.

The above-cited practices also do not violate any of the State's health and safety standards, an important aspect to be kept in mind in planning conservation efforts. The students made very careful studies of their conservation proposals before finally recommending them to the administration. They were able to verify for example, that reducing the light out-put from the corridor fixtures neither violated the code for proper lighting nor hindered the operating efficiency of the ceiling fixture.

"The first step in launching a systematic conservation of energy program is the administration office," Quint urges. "It is important to gain the support of your school administration before attempting to remove light bulbs or tubes, adjusting thermostats. Gaining the support of the custodian (a very important member of the conservation team) is a must. Once the administration understands your goals and is convinced you are organized and prepared to show results, it should be only too happy to support your efforts, which will eventually reap cost savings and add dollars to the school's budget – dollars which could be spent towards educational needs."*

This past Spring, Quint and some of his students attended a youth energy conservation workshop in Trenton, and found that most schools had not yet begun a systematic practical conservation operation. West Deptford students were most happy to share their success story and encourage other students to initiate a similar conservation program in their own schools. Just how much success they will have and just how long it will take before the majority acquire an energy ethic in keeping with the times, depends on many factors, always beginning with that basic ingredient – individual effort!

At the August 1976 West Deptford Board of Education Public Meeting, the Board publicly commended Quint for his fruitful efforts at energy conservation in the school.

*Some districts in other states, it is reported, are offering student incentives by sharing with them, through their activity programs, etc., the savings accruing to their energy conservation efforts.

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GUIDELINES FOR DEVELOPING AN ENERGY MANAGEMENT PLAN FOR LOCAL SCHOOL DISTRICTS

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ADMINISTRATIVE COMMITMENT

The planning, development, implementation, and evaluation of a district-wide energy conservation program will necessitate participation by virtually everyone in the district. The key to realizing such extensive cooperation is skillful leadership. No educational program has much chance for succeeding without an effective leader who is committed to its success. Similarly, a comprehensive energy management program relies on administrative support. This commitment must be fully and effectively communicated throughout the district so that there is no question as to where the administration stands on the issue. General awareness of administrative commitment serves two purposes: it encourages program support and it informs participants about the direction in which the school district will be moving and the course of future decision-making.

An astute administrator will recognize that the energy crisis cuts across all barriers created by instructional levels, departments, professions, etc.; it is an interdisciplinary, interdepartmental concern and responsibility. The administrator will understand the universality of energy concerns and will encourage this recognition throughout the district. The administrator's commitment is infectious: it will motivate constructive conservation activities. A district without this supportive leadership will be much slower to conserve energy.

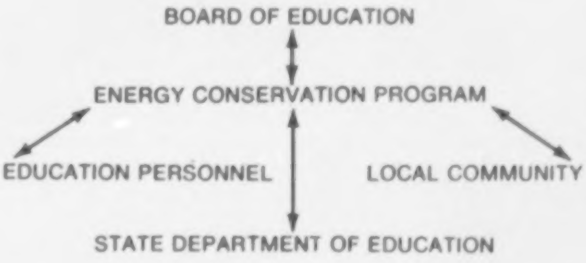
In addition to verbal commitment, the administrator must carefully prepare a preliminary energy management plan and develop alternative courses of action for initiating, maintaining, and/or extending conservation on a district-wide basis both immediately and in the future.

BOARD OF EDUCATION COMMITMENT

As an agent of the state, the local school district board of education is a policy-making body with responsibilities for managing the district itself and for linking the school district with the community and state. Boards of education seem to constantly exist "between a rock and a hard place:" they must successfully balance the expectations of the state department, the needs and expectations of the local community, and the needs and expectations of the administration and staff.

Money is always a critical factor that threatens to upset this balance, and the monetary implications of rising fuel costs have caused major disturbances in many school districts. Yet, in confrontation with this serious problem, it is possible for a shrewd administrator to provide the board with opportunities for enhanced communication and cooperation with the state department, the local community, and the education personnel.

Viewed positively, the energy crisis can encourage communication and cooperation in the following relationship:



The board's commitment to a comprehensive energy conservation program will involve the state department, the local community, and the education personnel in planning, developing, implementing and evaluating the program.

The energy crisis affects everyone connected with schools and presents two dimensions of commonality on which boards of education and administrators can capitalize: (1) an interest in saving money and (2) an interest in conserving energy. A strategically planned energy conservation program will emphasize these common concerns and thereby avoid the partisanship which occasionally obstructs cooperation among these groups.

Following are good reasons for initiating a comprehensive energy conservation program:

- It can provide the board of education with a means of retrieving valuable tax dollars that are wasted by inefficient energy use.
- It can provide the board of education with a means for alleviating the impact of the energy crisis on schools.
- It can provide the board of education with a means of enhancing communication and cooperation among the state department of education, the local community, and the education personnel.

The board of education of a local school district must be made aware of its responsibility in eliminating energy waste in schools. Commitment of the school district to a comprehensive energy conservation program will benefit everyone.

STATE DEPARTMENT OF EDUCATION

The state department of education should be kept informed about the institution and progress of energy conservation programs on the local level. The state department may have (if not, it should be encouraged to develop one) a state-wide energy conservation program. It may be able to provide materials, guidelines and consultants as well as general assistance to the local energy conservation team.

Representatives of the state department of education are familiar with state and federal legislation pertaining to energy conservation in school facilities and may be able to provide the local district with assistance in meeting pertinent state and federal guidelines. The state department may also be called upon for assistance in applying for whatever state and federal funding may be available to support conservation on the local education agency level.

ENERGY MANAGEMENT COMMITTEE

Once the board of education has committed the school district to initiating an Energy Conservation Program, it is advisable that they establish an advisory Energy Management Committee with policy-making responsibility for the prospective program. Policies formed by the Energy Management Committee will provide parameters within which the operational decision-making of an Energy Conservation Team can develop. In view of the Energy Management Committee's policy-making responsibility, it is important that the members of the Committee possess sufficient policy-making skills and the authority to insure the execution of their energy management policies. Also, it is important to point out that the Energy Management Committee is the board of education's decision-making vehicle and all eventual policy recommendations must be officially approved by the board of education.

It is recommended that the Energy Management Committee be selected by the board of education and include:

Member(s) of the board of education
Superintendent of Schools
District energy manager
District facility planner(s)
District public relations persons
Other central office staff
Energy expert(s)

ENERGY CONSERVATION TEAM COMPOSITION

Everyone who will ultimately be affected by the implementation of an energy conservation program should be involved in its operation and represented during its planning.

The chief administrator is aware of the political realities within the district and should be able to compose a team that will be technically and administratively effective. The team should have operational authority over all aspects of energy management. Responsibility for administering the energy conservation program should be assigned to ONE district energy manager who is directly accountable to the Energy Management Committee. This arrangement will provide the manager and the program with status and authority necessary to insure its success. The district energy manager need not be an existing central-office administrator, but must be someone with sufficient program management skills.

In addition to the district energy manager, an energy management team might consist of at least the following:

building principals
teachers from various instructional levels/departments
student representatives
maintenance and custodial staff supervisor
transportation staff supervisor
school business administrator
representatives from various parent and community advisory councils or organizations
a representative from the utility companies serving the district
outside professionals such as state department consultants, energy audit consultants, architects, engineers, college and university consultants, program management and evaluation consultants.

The size of the team will be dictated by the needs and expectations of the district. It should be large enough to include all areas of major responsibility without becoming unwieldy in the face of significant program decisions. The composition of the team is a key factor in the eventual success or failure of the conservation program. Team members should be committed to reducing energy consumption by motivating positive attitudes and activities. They will be responsible for organizing, training, supervising, and evaluating task forces within their given areas of administration.

ENERGY CONSERVATION TEAM IN-SERVICE EDUCATION AND TRAINING

In-service education and training will contribute to the success of the energy conservation program. Too often in education, a program is instituted without providing those responsible for its implementation with the skills necessary to get the job done effectively. Participants need implementation skills and a common frame of reference regarding program needs and goals. This is especially true in a program that cuts across numerous areas of responsibility. Members of the energy conservation team should receive extensive, on-going education and training in all planning, developmental, implementation and evaluation aspects of the conservation program. Team members will in turn be responsible for training members of their respective task forces. It is recommended that the district energy manager be responsible for this in-service education and training.

Members of the energy conservation team should be thoroughly familiar with the impact of the energy crisis in their schools because they will serve as liaison to the district regarding the energy crisis in general and its local impact. Team members should possess complete, accurate information about energy use/cost in their district. In addition, they should know how to conduct an energy mini-audit. (A mini-audit is a walk-through appraisal of building/equipment condition and user conduct. Problems identified by the mini-audit can usually be rectified quickly at little or no cost.) More extensive energy audits (maxi-audits) can be conducted by technical consultants-architects and engineers.

Members of the energy conservation team should collect data essential for needs assessment, decision-making, energy monitoring and evaluation. Knowing what data to collect and when to collect it is essential to effective decision-making. Once the energy use of the district has been assessed, team members must know how to convert this information into program goals, objectives, and activities.

Program goals will provide the direction of future program decision-making. Each team member will distill from the program goals task force objectives and activities. In-service training programs should give team members skills for formulating program goals and activities.

Members of the energy conservation team will also need supervisory skills. Although most members of the team occupy administrative or supervisory positions, their skills may need to be reinforced and made relevant to the energy conservation program.

In addition, a uniform system for monitoring and evaluating the progress and results of the program must be developed to insure that performance expectations are uniform district-wide.

The district energy manager will be responsible for providing experts and consultants to conduct in-service training and education. He/she will establish a firm, common frame of reference among members of the energy conservation team.

ANALYSIS OF SCHOOL DISTRICT ENERGY USE: ENERGY REPORTING AND AUDITING

The first major program activity which the energy conservation team will arrange is a thorough and accurate report on the energy (all fuels) used by each facility in the district. Detailed energy reports are the bases of the energy management program and must be furnished on a regular, periodic basis. Energy reporting is not a one-shot activity.

Next, a series of audits analyzing energy conservation opportunities in each facility are undertaken. There are two types of energy audit: mini audits which can be accomplished by trained team members and maxi audits which require professional services. The team will need to develop or adopt mini-audit instruments and procedures and organize task forces to implement them. Mobilizing task forces at this initial program phase allows controlled opportunities for district-wide participation.

The energy conservation team, particularly the district energy manager, plans and schedules comprehensive maxi-audits which pinpoint specific refitting requirements — building renovation and/or systems conversion. Maxi-audits produce recommendations which involve capital investment and time.

Once the energy reports and audits are complete, the energy conservation team will analyze the results and develop a program of activities for reducing fuel use. This analysis will consider the various time frames and costs for adjusting operation/maintenance practices, building renovation, building use and scheduling, equipment replacement, and so forth. Program formulation will involve life cycle cost computations which elucidates the long-range life costs, rather than first cost only, of capital investments and explores the benefits resulting from such expenditure. Alternative energy conservation programs are developed and examined in terms of cost benefits; the most satisfactory one is selected for submission to the Energy Management Committee for approval.

The procedure described above can be summarized:

1. Accurate, detailed energy use reports are prepared for each facility in the district.
2. The energy management team receives training in conducting mini-audits.
3. Mini-audits are conducted in each facility to determine what immediate changes can be made in the use of school buildings and equipment which will reduce fuel consumption.
4. Technical experts are hired to conduct maxi-audits which identify building and equipment modifications which will lower fuel use.
5. The energy management team analyzes the mini/maxi audit results and develops a program for modifying habits of building users (like turning out unneeded lights, lowering thermostats, etc.). The program involves mainly information dissemination, energy conservation publicity, and encouragement.
6. Maxi audit results and recommendations are analyzed with respect to time and cost/benefits, alternative energy management programs are developed.
7. The preferred energy management plan is selected by the team and submitted to the Energy Management Committee for approval.

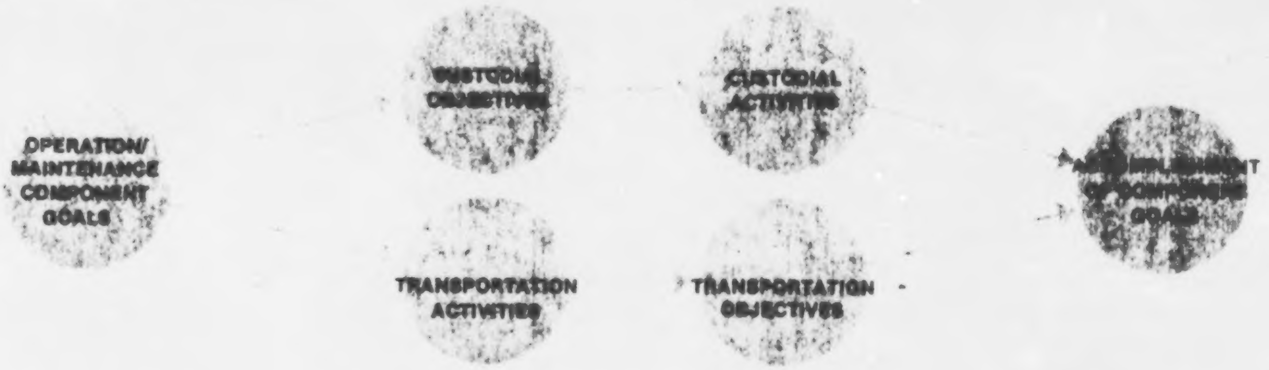
For further information on energy audits refer to "Three Energy Conservation Audits for Schools" in the section *Auditing Energy Use*.

DETERMINATION OF PROGRAM GOALS, OBJECTIVES, AND ACTIVITIES

Once the Energy Management Committee has acted upon the energy conservation team's recommendations, the team must translate the approved measures into program goals. Goals state what the program is expected to accomplish and give direction to future operational decision making.

Goals may be organized into time frames. For instance, goals related to building operation may be initiated almost immediately whereas goals related to modification of the building require more time and planning. Program goals should be measurable. For instance, a program goal might state that the district will reduce its annual consumption of energy fuels by 20% the first year. This program goal includes (1) a time frame of one year and (2) a measuring criterion of 20% reduction. Comparison of actual fuel reduction with the goal allows an assessment of program success and provides a basis for formulating future goals.

Translating the energy conservation program goals into objectives and task force activities requires specifically defining responsibilities of various groups in the district. Objectives are sub-goals on which the overall program goals depends. If the energy conservation team adequately represents all areas of responsibility within a school district, the subgoals or objectives it defines should, as a unit, produce a comprehensive program. This relationship is illustrated below:



Once it has been determined *what* needs to be accomplished in each area of responsibility, it must be determined *how* each objective will be achieved. For example, the custodial and maintenance supervisor may determine that in order to reduce consumption of fuel oil by 20% without impairing heating adequacy, the water temperature in hot-water boilers can be reduced from 180°F to 140°F. Also he may decide to remove alternate fluorescent lights from hallways in all buildings in order to reduce electricity consumption by 10%. Classroom and office thermostats may be turned down to 68°F. In order to reduce gasoline consumption by 20%, the school bus routes may be revised. These activities accomplish the specific objectives described.

The program objectives that each team member will strive to achieve are derived and agreed upon by all members of the energy conservation team. Each team member participates in the formulation of program goals and understands their implications from all perspectives. With communication and cooperation among team members at the start regarding what needs to be accomplished in each area, the possibility of conflict during implementation should be reduced considerably. Each member has the opportunity of viewing the energy conservation program and his particular area of responsibility in the context of the total system rather than in isolation. Problems that arise in latter phases of the program then become *team* rather than *individual* concerns.

PROGRAM IMPLEMENTATION

Implementation involves putting into operation that which has been planned. Energy conservation team members reorganize the task forces within their areas of responsibility if necessary. (Task forces were originally organized during the needs assessment phase of the program.) Training may be required to carry out the task force activities. Once task force activities are operational, the team members will supervise and monitor their implementation on a regular basis.

Each member of the energy conservation team will report to the team on task force progress. At regular team meetings necessary modifications in task force activities and program objectives should be discussed and acted upon. Implementation evaluation and progress evaluation results serve as the information base for discussion and modification.

PROGRAM EVALUATION

Evaluation will tell whether or not the energy conservation program accomplished what it set out to do. This feedback system supplies information for on-going and future decision-making. The energy conservation team will need to answer three questions:

1. Are the task force activities being implemented and to what extent?
2. Are the task force activities actually meeting the stated program objectives and to what extent?
3. Did the stated program objectives accomplish the program goals?

Question #1 above is an implementation evaluation, a monitoring process to determine if task force activities have been implemented as planned. It is an on-going, record-keeping instrument that should be maintained by each team member.

Question #2 is a progress evaluation which seeks information about the effectiveness of the task force in achieving stated objectives. This information can be used to modify the task force activities or the stated objectives where necessary. By conducting progress evaluations regularly at the indicated time frames for accomplishing program goals, the energy conservation team will *not* need to wait until the end of the program to find out which task force activities succeeded or failed.

Question #3 is an outcome evaluation measuring how effective the fully developed energy conservation program has been and estimating future program effectiveness. This phase of evaluation is particularly important in a district which has instituted only a pilot program. An outcome evaluation instrument will provide the team with information about the effectiveness of program objectives in accomplishing program goals. An effective outcome evaluation instrument will also provide clues as to how the objectives should be modified to more adequately accomplish the chosen program goals.

All three program evaluations will need to be developed and conducted by the energy conservation team. An outside evaluation team may be hired to work with the team.

When extensive resources have been committed to managing energy use, it is only sensible to also commit sufficient resources to allow thorough evaluation of the program.

COMMUNICATIONS/PUBLIC RELATIONS

The energy crisis touches all areas of responsibility in a school district. It is therefore important that the total educational and lay communities be informed about energy costs and use in the district and about measures for their reduction. The energy conservation team should be identified and its activities publicized. The energy conservation program should be a matter of common knowledge and its results should be communicated. Therefore, it is recommended that an energy conservation public relations program be developed, implemented and evaluated by a selected task force of the energy conservation team.

These activities might be incorporated in a public relations program:

1. Develop a theme for the energy conservation program that is simple, catchy, and provides emotional appeal.
2. Develop a logo to represent the energy conservation goals of the school district.
3. Develop speech packages for the members of the energy conservation team and energy management committee.
4. Design flyers, brochures, yard signs, post cards, envelope stickers, buttons, and display materials that emphasize the importance of the program.
5. Develop information packets on the energy conservation program for all media outlets.
6. Seek out and train a diverse group of community volunteers who can represent the program.
7. Design newspaper "ad slicks" for the program.
8. Prepare feature stories on volunteers, teachers, administrators, students, custodians, food service personnel, transportation personnel, experts and consultants, etc., emphasizing their respective roles in the program.
9. Seek endorsements from local business people, public officials, religious and social organizations, etc.
10. Develop a public relations report on the implementation, progress, and outcome evaluation information of the energy conservation program.
11. Develop survey instruments to periodically test the pulse of public opinion regarding the energy crisis and the effects of the conservation program.

As the energy conservation program unfolds, printed materials should be disseminated and speaking engagements should be made. Radio, television, and newspaper advertisements should be arranged on a regular basis; every media outlet should be visited and provided with information packages; the feature stories should be published in planned sequence. The program theme and logo must be a dominant feature in the public eyes and ears

SECTION IV

ANNOTATED AND GENERAL BIBLIOGRAPHIES

Selected Bibliography of Energy Materials for Schools

Compiled by Frederick C. Ryan, Jr.

Educational Improvement Center, Central Jersey

In the compilation of this bibliography, the primary concern has been to provide materials that can be acquired by teachers or administrators and readily be put to use in their schools. Thus, the emphasis has been on curricular materials and books for students rather than reference or technical works that would form the basis of an energy library. An excellent annotated list of such works can be found in the January 1, 1977 issue of Library Journal.

This bibliography is divided into two sections: An annotated list of curricular materials and a general list of books suitable for use by students. The annotated list is further divided into sections: a general listing, including K-12 materials, an elementary section, a secondary section, and a section of listing one or two items administrators can use in developing energy-efficient schools. In all sections the source of the materials is listed. However, due to time constraints, it was not possible to test the availability of the materials, so that some works, especially less recent ones, may be out of print.

This bibliography was gleaned from several sources. Since only a selection of curricular materials could be presented here, an annotated list of these sources has been provided for those teachers and administrators seeking more complete listings of information. In addition to the listed sources, the resources of the following groups have been used in compiling this bibliography:

Educational Improvement Center - South Jersey
P. O. Box 426
Pitman, New Jersey 08071

Institute for Science-Technology-Social Science Education
Rutgers University - Busch Campus
Doolittle Building, Room #103
New Brunswick, New Jersey 08903

Project DOE (Decisions on Energy)
Manasquan Public Schools
Manasquan, New Jersey 08736

Their assistance in this effort is greatly appreciated.

Annotated List of Curricular Materials

I. General, including K-12 Materials

Create Tomorrow ....Today: An Energy Awareness Program, 1974. This attractive and comprehensive publication is an activities guide, a source of information on energy and a resource book. The activities are designed for flexibility so that both group and individual efforts are provided. Includes charts, bibliography and a glossary. Available from: Supervisor of Environmental Education Programs, Washington State Department of Public Instruction, Old Capitol Building, Olympia, WA 98504.

Energy and Man's Environment, 1975. A comprehensive guide, EME offers a number of services, including activity guides, in-service teacher seminars, and special curriculum projects. Contains charts, activity guide, glossary and a bibliography. Available from: EME, P.O. Box 200, Beaverton, Oregon.

Energy Conservation - Guidelines for Action, 1974. Contains curriculum guidelines and background information for teachers, plus sample activities. Available from: Region Nine Superintendent, Michigan Association of School Administrators, 421 W. Kalamazoo St., Lansing, MI 48933.

Energy Crisis: A Teacher's Resource Guide, (1974). Contains objectives, background content, activities, references, and examples of measuring devices for every classroom use. NJEA Review 47: pp. 33-34, February, 1974. Reprints available from New Jersey Education Association, 180 W. State Street, Trenton, New Jersey, 08608.

Energy Crisis: Teaching Resources, 1974. Suggests schools activities which stress individual responsibility toward energy crisis problems. Includes bibliography, checklists and graphs and charts indicating energy usage and expenditures. Available from: Oregon State Department of Education, 942 Lancaster Drive NE, Salem, OR 97310.

Energy-Environment Mini-Unit Guide, 1975. This unit is part of a three-part National Science Teachers Association (NSTA) series on energy-environment (other parts are described elsewhere in this bibliography). This part is a collection of mini-units that provide materials for science and social studies teachers in grades K-12. These materials are intended to make teaching more interdisciplinary and to stimulate decision-making in children. Available from: National Science Teachers Association, 1742 Connecticut Avenue, NW, Washington, D.C. 20009. (Price - $3.00)

Energy-Environment Source Book, 1975. This book, one of the three-part NSTA series on energy environment, is written for teachers who wish to incorporate material on the complex subject of energy into their teaching. This work is divided into two volumes, each with numberous tables and figures, Volume I: Energy, Society and the Environment deals with energy, conservation, the enviornment and the economy. Volume 2: Energy, Its Extraction, Conversion, and Use deals with energy consumption, cost and future sources. Available from: National Science Teachers Association, 1742 Connecticut Avenue, N.W. Washington, D.C. 20009. (Price - $4.00)

Energy: Key to the Future, 1974. Teaching techniques for the understanding and conservation of energy, K-12. Available from: Dutchess County Board of Cooperative Educational Services, Route #1, Salt Point Turnpike, Poughkeepsie, N.Y. 12601.

Energy Materials, 1974. A comprehensive energy-environment resource materials guide, containing a detailed bibliography (including A-V materials), a list of classroom activities K-12, and a brief glossary of energy terms. Available from: Associate Superintendent for Instruction and Professional Education, State of Iowa, Department of Public Instruction, Grimes State Office Building, Des Moines, IA 50319.

Environmental Education Guide K-12, 1974. "Investigations" into environmental problems providing lists of goals and objectives together with suggested questions and an annotated bibliography. Available from: Divisions of Elementary, Secondary and Vocational Education, State Department of Education, Richmond, VA23216.

Environmental Education Strategies for Wise Use of Energy. This K-12 guide provides instructional activities, energy "IQ" tests, charts, checklists and a bibliography; also, useful graphs and other visuals. Available from: Division of Science Education, North Carolina Department of Public Instruction, Raleigh, NC 27611.

Do We Understand Energy?, 1974. A brief handbook relating to the use and conservation of energy, describing sources of energy and containing conservation checklists and a teacher's guide to energy-related activities. Available from: Division of Instruction, Bureau of Instruction and Curriculum, West Virginia Department of Education, Charlestown, WV 25305.

Greep on Energy. K-12 mini-units designed by students to be taught to other students with the teacher as facilitator. Available from: Project S.E.E., Wyandotte Public Schools, 891 Goddard Rd., Wyandotte, MI 48192.

Living Within Our Means: Energy and Scarcity. Interdisciplinary approach, including activities for English Language Arts, Social Studies, Mathematics and Science. Available from: Environmental Education, University of the State of New York, State Department of Education, Albany, N.Y. 12224.

Multi-unit Guide, 1975. Part of the NSTA Energy Environment Materials Project, each multi-unit is designed to be a complete unit. The teacher does not need to provide any additional material or go to any reference outside the Source Book, one of the NSTA products. Available from: (See reference under "Sources" - The NSTA Energy Environment Materials Project.

Priority One: Environment, 1976. Nationally validated ESEA Title III Program. Our component of this program is "The Energy Challenge", a curriculum with five sections: The Energy Consumer, Problems of Supply and Demand, Evaluation of Present Sources, Evaluation of New Sources, Providing for the Future. Available from: Pollution Control Education Center, Union Township Public Schools, Union, N.J.

A Teacher's Handbook on Energy, 1974. Compiled by teachers, science advisors and environmental education specialists in Colorado, this Handbook contains background information on energy, checklists, classroom activities, information on conservation and a bibliography. Available from: Director, Supporting Services Unit, Colorado Department of Education, 201 E. Colfax Avenue, Denver, CO 80203.

A Thousand Suns. Award winning 16mm film on energy, divided into three parts: One, the sun as a source of energy and man's ability to control nuclear fusion. Two, a look at energy capabilities and the relationship between use and waste. Three, viable alternatives. Available from Department G.F.A., Arthur Barr Productions, Inc., P.O. Box 7-C, Pasadina, CA 91104. Purchase, $140.00, rental, $15.00. For further information, write Supervisor of Environmental Education Programs, Washington State Department of Public Instruction, Old Capitol Building, Olympia, WA 98504.

II. Elementary Materials

Environmental Education Instructional Activities (K-6), 1972. Aesthetically pleasing activity guide, covering subjects such as survival, interdependence, scarcity and social forces. Available from: Environmental Education, University of the State of New York, State Department of Education, Albany, N.Y. 12224.

A Teacher's Introduction to Energy and Energy Conservation: Elementary, 1975. This document is intended to give the elementary school teacher background information and general suggestions for teaching units and learning activities related to energy and energy conservation. Available from: Division of Education, Redesign and Renewal, Ohio Department of Education, 65 South Front Street, Columbus, Ohio 43215.

III. Secondary Materials

Conservation Curriculum Improvement Project (CCIP) Guides. Energy topics in guides for Grade 5, Physical Science, Grade 9, Social Studies, Grades 7,8, & 9. These interdisciplinary guides are available at $3.95 each. Available from: Curriculum Development Section, South Carolina State Department of Education, Room 801, Rutledge Building, Columbia, SC 29201.

Energy Activities and Resources for the Secondary Student, 1975. Energy-related materials (7-12), including several interdiscipinary activities, for the purpose of creating within the student an awareness of energy-related problems through involvement. Available from: Kingsport City Schools, Environment Education Program, Kingsport, TN 37664.

Environment and Society: People and Cities, 1974. An activity guide for dwellers in the urban environment. Available from: University of the State of New York, State Department of Education, Bureau of Continuing Education Curriculum Development, Albany, N. Y. 12224.

The Environmental Impact of Electrical Power Generation: Nuclear and Fossil, 1973. This publication discusses U.S. energy production and demand and contains an energy conservation bibliography and a glossary of terms. Available from: Pensylvania Department of Education, Division of Science and Technology, Bureau of Curriculum Services, Box 911, Harrisburg, PA 17126.

Environmental Education Instruction Activities (7-12), 1972. Aesthetically pleasing activity guide, covering such subjects as survival, interdependency scarcity and social forces. Available from: Environmental Education, University of the State of New York, State Department of Education, Albany, N.Y. 12224.

Implementing Energy Education in Florida's High Schools, 1976. Curriculum units developed by high school teachers are provided for specific content areas: social studies, science and home economics. Available from: Energy Research and Development Administration, Washington, D.C.

A Teacher's Introduction to Energy and Energy Conservation: Secondary, 1975. This document is intended to give the secondary school teacher background information and give general suggestions for teaching units and learning activities related to energy and energy conservation. Available from: Division of Educational Redesign and Renewal, Ohio Department of Education, 65 South Front Street, Columbus, Ohio 43215.

IV. Facility Materials

Life-Cycle Costing. Educational Facilities Digests, 1976. This work provides a management tool that may assist school administrators in making cost-effective decisions about building and improving school facilities. An overview of recent literature on this topic is presented. Available from: Council of Educational Facilities Planners International, 29 West Woodruff Avenue, Columbus, Ohio 43210.

A Model For Education: Energy-Water Consumption Decision Making, 1977. Districts can calculate the amount and cost of energy per pupil by utilizing records, enrollment and attendance figures and building measurements. Examples are given. Available from: ERIC.

V. Source Materials

Children's Edition of Selected Publications on the Environment, 1973. A catalog of 29 items of interest to environmental educators. Available from: Office of Public Affairs, U.S EPA, Washington, D.C. 20460.

Energy Conservation Materials Package, 1975. Produced by the Interstate Energy Conservation Leadership Project, an ESEA Title V-505 project, which maintains an energy conservation clearinghouse, established and operated for the specific purpose of assisting state education personnel with energy matters. For further information contact: IECL Clearinghouse, Colorado Department of Education, 201 E. Colfax Avenue, Denver, CO 80203. Direct requests for materials should be addressed to: Clearinghouse Librarian, Colorado State Library, 1362 Lincoln Street, Denver, CO 80203.

The Energy Crisis - Aids to Study, 1974. Compiled for U.S. Office of Education, this work is a bibliography of books, magazine articles and curriculum aids. Available from: Massachusetts Audubon Society, Hatheway Environmental Institute, Lincoln, MA 01773.

Energy Education Materials Inventory, 1976. This catalog of available materials is published in five parts. Each part gives the following information: title, author, availability, cost, grade level, related materials and an evaluation of the materials.

Part I lists printed materials, including teachers guides, curriculum guides, ditto masters, textbooks, pamphlets, and posters.

Part II lists non-print materials: films, filmstrips, slides, transparencies, audio-tapes, and records.

Part III lists 16mm films.

Part IV lists kits, games, and miscellaneous curricula.

Part V lists complete sources of information, directories, educational programs, funded projects, periodicals and journals.

Available from: Federal Energy Administration, Washington, D.C. Also available on microfiche from ERIC.

Energy-Environment Materials Guide, 1975. This guide, one part of the three-part NSTA series on energy-environment, is a sampling of current energy literature. The reference are divided into four separate categories: readings for teachers and readings for students grades 8-10, grades 5-9, and grades K-6. Also included are guides for films and A-V materials, curriculum materials, sources of information and government documents. Available from: National Science Teachers Association, 1742 Connecticut Avenue, NW, Washington, D.C. 20009. (Price - $2.00)

ERIC Abstracts: ERIC Documents Resumes on Energy Conservation and the Schools, ERIC Abstract Series, Number 35, 1976. This source provides abstracts of documents in the ERIC system related to the headings "energy", "energy conservation", and "energy crisis". Available from: American Association of School Administrators, 1801 North Moore Street, Arlington, VA 22209. This source also tells how to order ERIC documents and microfiche.

The NSTA Energy - Environment Materials Project, 1975. Materials for teachers produced by the National Science Teachers Association under contract to the U.S. Office of Education (contract #OEC-0-74-8736), comprised of three products:

1) Source Book, in two volumes - Vol. I, Energy, Society and the Environment, deals with matters of policy. Vol. II, Energy, Its Extraction, Conservation and Use, is technical and scientific. Collectively, both volumes provide interdisciplinary information.

2) Multi-unit Guide contains seven learning packages which teachers can use to involve students in energy matters, ranging K-12.

3) Materials Guide - an annotated resource reference including a teacher bibliography broken down into topic areas and annotated to give the teacher a content review of each reference and appropriate information source.

Available from: NSTA-EEMP, The National Science Teachers Association, 1742 Connecticut Avenue, NW Washington, DC 20009.

Tennessee Environment Center (TEC). The TEC has produced a number of publications of interest to the general public on the subject of energy conservation. Available from: University of Tennessee, South Stadium Hall, Knoxville, TN 37916.

General Bibliography of Books for Students

Knowles, Ruth Sheldon, *American's Oil Famine,* Coward & Co., N.Y. 1975.

Butterworth, W.E., *Black Gold*, Four Winds Press, N.Y. 1975.

Dennis, Landt, *Catch The Wind*, Four Winds Press, N.Y. 1976.

Keeler, Andrew G. & Fritsch, Albert J., *A Citizen's Oil Factbook*, Center For Science in the Public Interest, Washington, D.C. 1976.

Halacy, Jr., *The Coming Age of Solar Energy*, Harper & Row, N.Y. 1973.

Gay, Larry, *The Complete Book of Heating With Wood*, Garden Way Publishers, Charlotte, Vermont., 1974.

Continuing Energy Crisis in America, Congressional Quarterly, 1975.

Fritsch, Albert J., *The Contrasumers*, Praeger Publishers, N.Y. 1974.

Munson, Richard, Ed., *Countdown To A Nuclear Moratorium*, Environmental Action Foundation, 1976.

Shuttleworth, Dorothy E., & Williams, Lee Ann, *Disappearing Energy, Can We End The Crisis?* Doubleday, N.Y. 1974.

Hite, James C., et al., *The Economics of Environment Quality*, American Enterprise Institute for Public Research, Washington, D.C. 1972.

Novick, Sheldon, *The Electric War*, Sierra Club Books, San Francisco, 1976.

Adler, Irving, *Energy*, John Day Co., N.Y. 1970.

Pine, Tillie S. and Levine, Joseph, *Energy All Around*, McGraw-Hill, N.Y. 1975.

Kaplan, William & Lebowitz, Melvyn, *Energy and Fuels*, Richards Rosen, N.Y. 1976.

Energy & Power, W.H. Freeman & Co., San Francisco, California 1971.

Coats, *Energy and Power*, G.P. Putnam's Sons, N.Y. 1967.

Hinkelbein, Ablert, *Energy & Power*, Franklin Watts, Inc., N.Y. 1971.

Irving, Robert, *Energy and Power*, Albert A. Knopf, N.Y. 1958.

Hammond, Allen L., et. al., *Energy and The Future*, American Association for the Advancement of Science, Washington, D.C. 1973.

Rothman, Milton A., *Energy and The Future*, Franklin Watts, Inc., 1975.

AIA Research Corporation, *Energy Conservation In Building Design*, 1974.

Rocks, Lawrence & Runyon, Richard P., *The Energy Crisis*, Crown Publishers, N.Y., 1972/

Szulc, Tad, *The Energy Crisis*, Franklin Watts, Inc., N.Y. 1974.

Mitchell, Edward J., *The Energy Dilemma*: *Which Way Out*? American Enterprise Institute for Public Research, Washington, D.C.

Wilson, Richards & Jones, Wm. J., *Energy*, *Ecology*, & *The Environment*, Academic Press, N.Y., 1974.

Steadman, Philip, *Energy*, *Environment and Building*, Cambridge University Press, 1975.

Clark, Wilson, *Energy For Survival*, Anchor Books, N.Y. 1971.

Clark, Wilson, *Energy For Survival - The Alternative To Extinction*, Anchor Books, 1975.

Branley, Franklin M., Energy For the 21st Century, Thomas Y. Crowell Co., N.Y. 1975.

Berger, Melvin, Energy From The Sun, Thomas Y. Crowell Co., 1976.

Marion, Jerry B., Energy In Perspective, Academic Press, N.Y. 1974.

Gutnik, Martin J., Energy: Its Past, Its Present, Its Future, Children's Press, Chicago, Illinois, 1975.

Gray, John E., Energy Policy: Industry Perspectives, Balling Pub. Co., Mass., 1975.

Mitchell, Edward J., Ed., Energy: Regional Goals and the National Interest, American Enterprise Institute for Public Research, Washington, 1976.

Hollomon, J. Herbert, et. al., Energy Research & Development, Ballinger Publ. Co., Cambridge, Mass. 1975.

Energy Self-Sufficiency, National Energy Project, 1974.

Kalter, Robert J. & Vogely, William A., Ed., Energy Supply and Government Policy, Cornell Univ. Press, N.Y. 1976.

Freeman, S. David, Energy - The New Era, Walker & Co, N.Y. 1974.

Halacy, Jr., D.S., The Energy Trap, Four Winds Press, N.Y. 1975.

Abelson, Philip H., Energy: Use Conservation & Supply, American Association for the Advancement of Science, 1974.

Wallace, Daniel, Ed., Energy We Can Live With, Rodale Press, Emmaus, PA, 1976.

Neigoff, Anne, The Energy Workers, Albert Whitman & Co., Chicago, Ill. 1975.

Eisenbud, Merril, *Environmental Radioactivity*, Academic Press, N.Y. 1973.

Care, R.A., *Fire & Fuels*, Mills & Boon, London, 1975.

Stoker, H. Stephen, et. al., *From Source to Use Energy*, Scott, Foresman & Co., 1975.

Fuel & Energy, Macdonald Educ., N.Y., 1975.

Marshall, James, *Going, Going, Gone?* Coward & Co., N.Y. 1976.

Weidenbaum, Murray L. & Harnish, Reno, *Government Credit Subsidies For Energy Development*, American Enterpise Institute for Public Research, Washington, D.C.

Knight, David C., *Harnessing The Sun*, Wm. Morrow & Co., N.Y. 1976.

Sullivan, George, *How Do They Find It?* The Westminster Press, Philadelphia 1975.

Mikdashi, Zuhayr, *The International Politics of Natural Resources*, Cornell Univ. Press, Ithaca, N.Y. 1976.

Is The Energy Crisis Contrived?, McCracken, Paul W. Moderator, AEI Roundtable Discussion July 22, 1974.

Pierotti, Anne & Fritsch, Albert J., *Lifestyle* Index-76, Center For Science In The Public Interest, Washington, D.C. 1976.

Ridpath, Ian, Ed., *Man And Materials-Gas*, Addison-Wesley, 1975.

Ridpath, Ian, Ed., *Man And Materials Coal*, Addison-Wesley, 1975.

Fanning, Leonard M., *Men, Money & Oil*, The World Publishing Co., N.Y. 1966.

Lenczowski, George, *Middle East Oil In A Revolutionary Age*, National Energy Project.

Clegg, Peter, New Low-Cost Sources Of Energy For The Home, Garden Way Publishing, Charlotte, Vermont, 1975.

Inglis, David Rittenhouse, Nuclear Energy: Its Physics and Its Social Challenge, Addison-Wesley, Mass., 1973.

Lewis, Richard S., The Nuclear-Power Rebellion, Viking Press, N.Y. 1972.

Bradley, Tom, Moderator AEI Roundtable Discussion March 21, 1975, Offshore Oil: Costs and Benefits

Gans, Roma, Oil, The Buried Treasure, Thomas Y. Crowell Co., N.Y. 1975.

Buehr, Walter, OIL - Today's Black Magic, Wm. Morrow & Co., N.Y. 1957.

Smaridge, Norah, Only Silly People Waste, Abingdon Press, N.Y. 1976.

Leckie, Jim et al., Other Homes & Garbage, Sierra Club Books, San Francisco, 1975.

Kash, Don E., et. al., Our Energy Future, Univ. of Oklahoma Press, 1976.

Fanning, Leonard, Over Mountains, Prairies & Seas, McGraw-Hill, N.Y. 1968.

Kern, Ken, The Owner Built Home, Charles Scribner's Sons, N.Y. 1972.

Gordon, Howard & Meador, Roy, Perspectives On The Energy Crisis, Ann Arbor Science. (Vol. I), Ann Arbor, Michigan, 1977.

Adler, Irving, Petroleum, John Day Co., N.Y. 1975.

Smith, Howard E., Play With The Sun, McGraw-Hill, N.Y., 1975.

Kenward, Michael, Potential Energy, Cambridge Univ. Press. N.Y. 1976.

Commoner, Barry, The Poverty of Power, Albert A. Knopf, N.Y. 1976.

Stoner, Carol Hupping, Ed., Producing Your Own Power, Rodale Press, Emmaus, PA 1974.

McFarland, Andrews S., *Public Interest Lobbies*, Studies In Energy Policy, 1976.

Mitchell, Edward J., *The Question of Offshore Oil*, Amer. Enterprise Inst. For Public Policy Research, Washington, 1976.

Peltzman, Sam, *Regulation of Automobile Safety*, Amer. Enterprise Inst. for Public Policy Research, Washington, D.C. 1975.

Rehabilitation Potential of Western Coal Lands, Balling Pub. Co., Mass, 1974.

Benjamin, Bernard et. al., *Resources And Population*, Academic Press, 1973.

Scarce World Resources, High School Debate Series, American Enterprise Institute for Public Research, Washington, D.C.

Pesko, Carolyn, *Solar Directory*, Ann Arbor Science Publ., Inc. Michigan 1975.

Szokolay, S.V., *Solar Energy and Building*, Architectural Press, Ltd., London, 1975.

AIA Research Corporation, *Solar Energy and Housing Design Concepts*, 1975.

Williams, J. Roberts, *Solar Energy-Technology & Applications*, Ann Arbor Science, Michigan 1977.

AIA Research Corporation, *Solar-Oriented Architecture*, 1975.

Morgan, Richard, et. al., *Taking Charge*, Environmental Action Foundation, 1976.

Spies, Henry R., et. al., *350 Ways to Save Energy & Money in Your Home & Car*, Crown Publishers, Inc., N.Y. 1974.

Gray, E.T. & Gasus, O.K., Ed., *Tidal Power*, Plenum Press, N.Y. 1972.

A Time To Choose, Ballinger Publ. Co., Cambridge, Mass. 1974.

Mitchell, Edw. J., and Chaffetz, Peter R., Toward Economy in Electric Power, National Energy Project, 1975.

Mitchell, Edward J., Two Talks On Energy Policy, Amer. Enterprise Inst., N.Y.

Mitchell, Edward J., U.S. Energy Policy: A Primer, National Energy Project, 1974.

Mintz, Ilse, U.S. Import Quotas: Costs & Consequences, American Enterprise Institute for Public Research, Washington, D.C. 1973.

Beame, Rona, What Happens To Garbage? Julian Messner Co., N.Y. 1975.

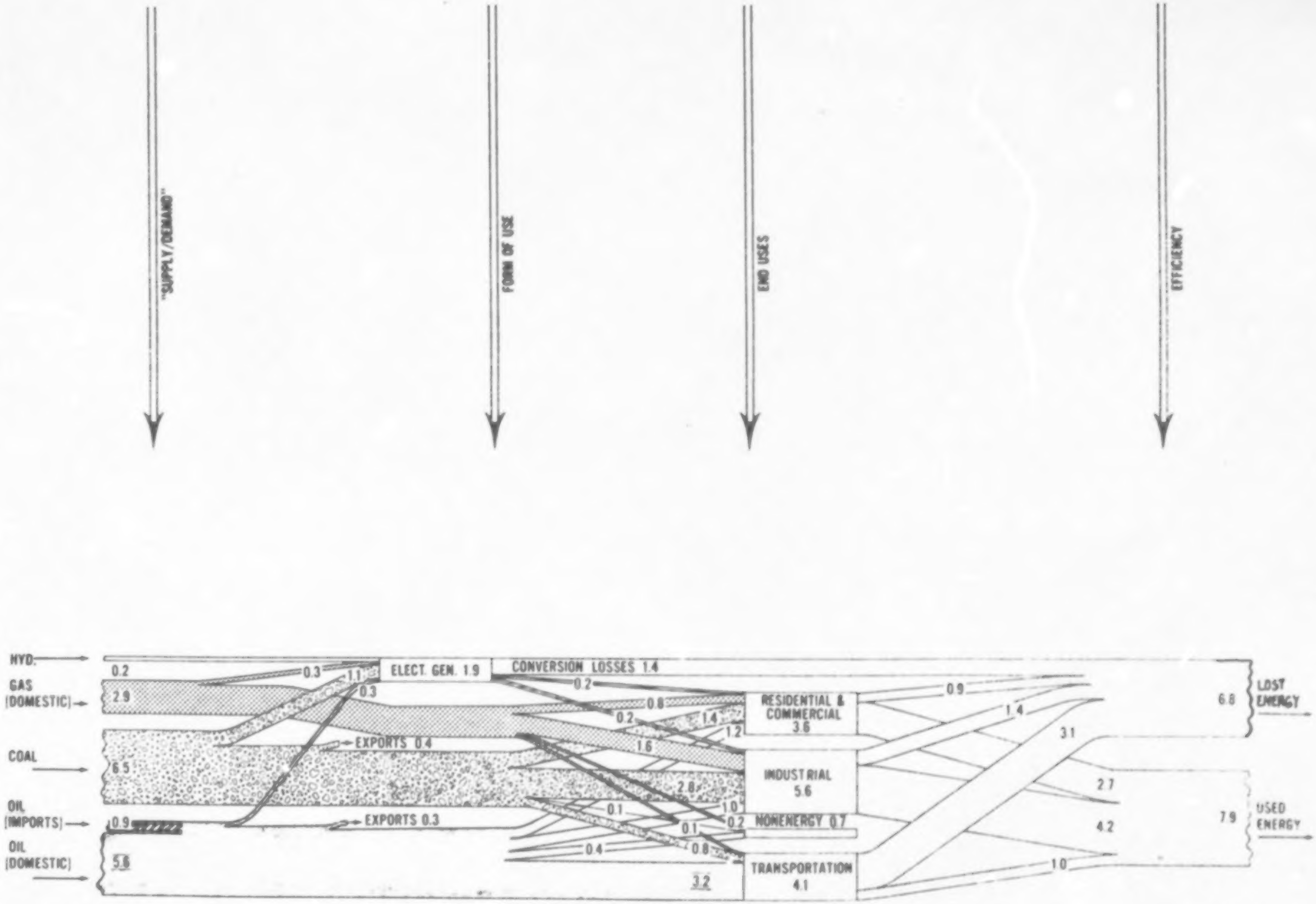
Doty, R., Where Are You Going With That Oil?, Doubleday & Co., N.Y. 1976.

Lovins, Amory B., World Energy Strategies, Friends of the Earty, 1975.

APPENDIX I

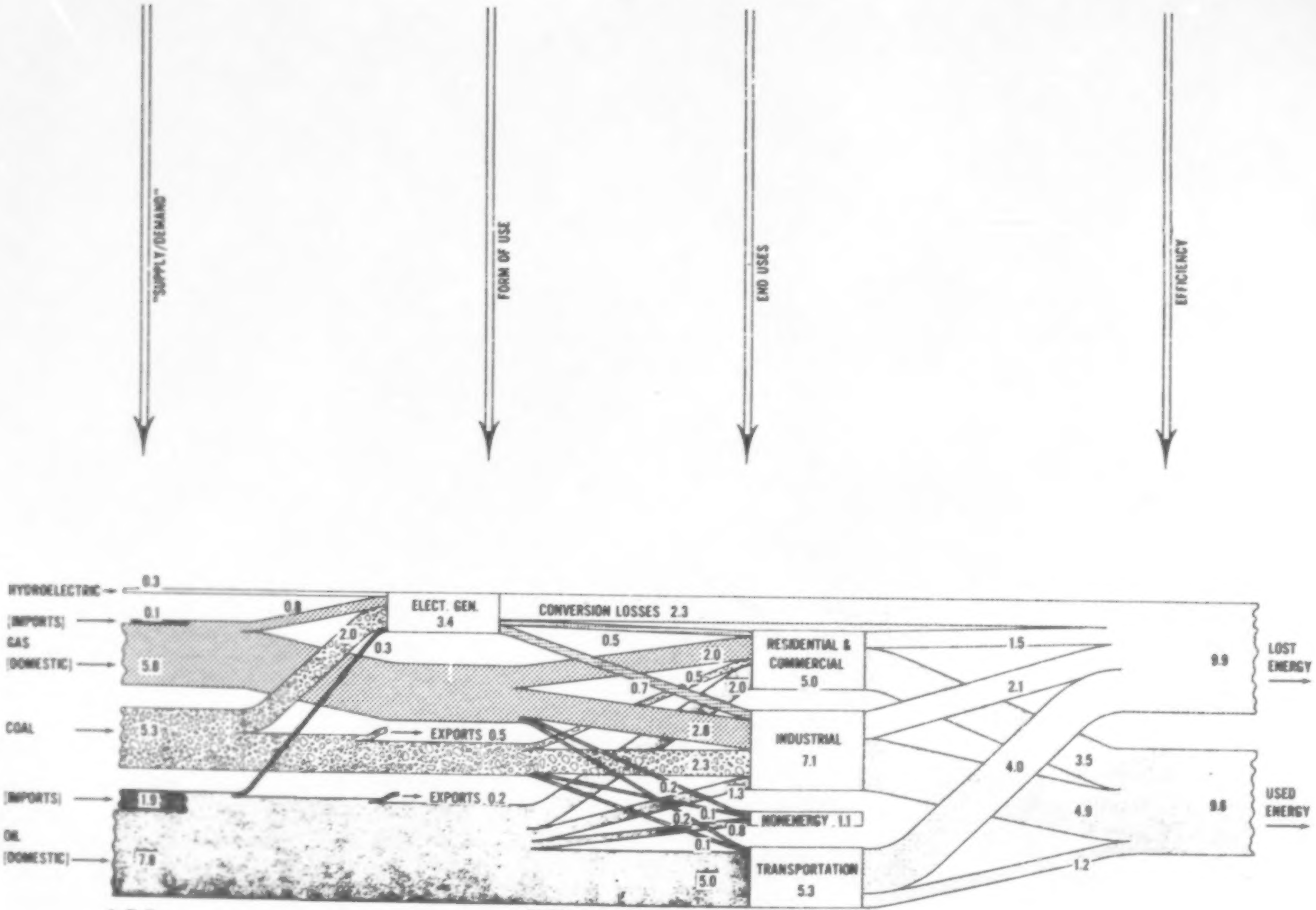
ENERGY FLOW PATTERNS
IN THE UNITED STATES

ENERGY FLOW PATTERN IN THE UNITED STATES - 1950


"SUPPLY/DEMAND"
FORM OF USE
END USES
EFFICIENCY
HYD.
0.2
GAS (DOMESTIC)
2.9
COAL
6.5
OIL (IMPORTS)
0.9
OIL (DOMESTIC)
5.6
0.3
1.1
0.3
EXPORTS 0.4
EXPORTS 0.3
ELECT. GEN. 1.9
CONVERSION LOSSES 1.4
0.2
0.8
0.2
1.4
1.2
1.6
2.8
1.0
0.1
0.2
0.1
0.4
0.8
3.2
RESIDENTIAL & COMMERCIAL 3.6
INDUSTRIAL 5.6
NONENERGY 0.7
TRANSPORTATION 4.1
0.9
1.4
3.1
2.7
4.2
1.0
6.8
LOST ENERGY
7.9
USED ENERGY

(UNITS: MILLION BBLS/DAY OIL EQUIVALENT)

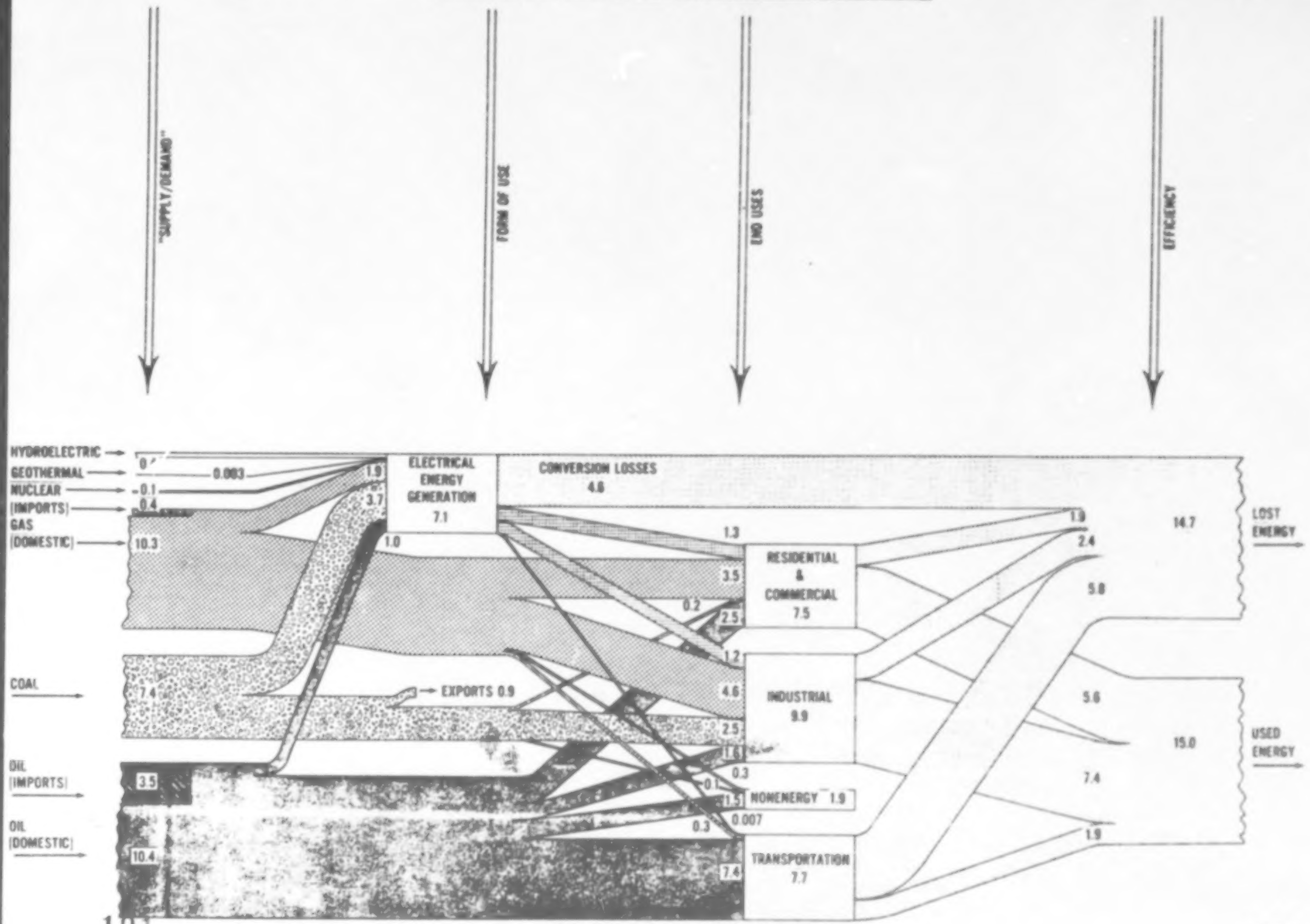
ENERGY FLOW PATTERN IN THE UNITED STATES - 1960


SUPPLY/DEMAND
FORM OF USE
END USES
EFFICIENCY
HYDROELECTRIC
0.3
(IMPORTS)
0.1
GAS
(DOMESTIC)
5.8
0.8
ELECT. GEN.
3.4
2.0
0.3
CONVERSION LOSSES 2.3
0.5
COAL
5.3
EXPORTS 0.5
(IMPORTS)
1.9
OIL
(DOMESTIC)
7.8
EXPORTS 0.2
2.0
0.5
0.7
2.0
2.8
2.3
0.2
1.3
0.1
0.2
0.8
0.1
5.0
RESIDENTIAL & COMMERCIAL
5.0
INDUSTRIAL
7.1
NONENERGY 1.1
TRANSPORTATION
5.3
1.5
2.1
4.0
3.5
4.9
1.2
9.9
LOST ENERGY
9.6
USED ENERGY

(UNITS: MILLION BBLS/DAY OIL EQUIVALENT)

APPENDIX I-2

ENERGY FLOW PATTERN IN THE UNITED STATES - 1970


"SUPPLY/DEMAND"
FORM OF USE
END USES
EFFICIENCY
HYDROELECTRIC
GEOTHERMAL
NUCLEAR
(IMPORTS)
GAS
(DOMESTIC)
COAL
OIL
(IMPORTS)
OIL
(DOMESTIC)
0
0.003
0.1
0.4
10.3
7.4
3.5
10.4
1.9
3.7
1.0
ELECTRICAL ENERGY GENERATION 7.1
CONVERSION LOSSES 4.6
EXPORTS 0.9
1.3
3.5
0.2
2.5
1.2
4.6
2.5
1.6
0.3
0.1
1.5
0.007
0.3
7.4
RESIDENTIAL & COMMERCIAL 7.5
INDUSTRIAL 9.9
NONENERGY 1.9
TRANSPORTATION 7.7
1.9
2.4
5.8
5.6
7.4
1.9
14.7
15.0
LOST ENERGY
USED ENERGY

(UNITS: MILLION BBLS/DAY OIL EQUIVALENT)

APPENDIX II

GLOSSARY

Glossary

absolute zero — The temperature at which, according to the general gas laws, a gas would exhibit no pressure. If substances were to behave as gases at all temperatures, the temperature at which random molecular energy is zero. It is equal to −273.16° Centigrade or −459.7° Fahrenheit.

alpha particle — The positively charged nucleus of a helium atom. A nuclear cluster consisting of two neutrons and two protons which is one of three types of emissions by naturally radioactive elements. It can also be produced through nuclear reactions.

ampere — A unit of measure for electric current. The charge flow per unit time. It is equivalent to a flow of approximately 6×10^{18} electrons per second.

annual rate of growth — The percentage by which a quantity increases each year.

base load — The minimum load of a utility (electric or gas) over a given period of time.

barrel (bbl) — A liquid measure of oil, usually crude oil, equal to 42 gallons or about 306 pounds.

bituminous coal — Soft coal; coal that is high in carbonaceous and volatile matter.

black lung — A respiratory ailment, similar to emphysema, which is caused by inhalation of coal dust. Identified as a contributing cause in the deaths of many underground coal miners.

bottoming cycle — A means of using the low-temperature heat energy exhausted from a heat engine, a steam turbine, for instance. It usually employs a low-boiling point-liquid as working fluid.

breeder reactor — A nuclear reactor so designed that it produces more fuel than it uses. Uranium 238 or thorium 232 can be converted to the fissile fuel, plutonium 239 or uranium 233, by the neutrons produced within the reactor core.

British Thermal Unit (BTU) — A unit of heat energy equal to the quantity of heat necessary to raise the temperature of one pound of water one degree Fahrenheit. It is equal to one-quarter of a Calorie.

brownout — The deliberate lowering of voltage (and, thus, the power supplied to all users) by electric utility companies, employed when demand for power exceeds generating capacity.

Calorie — A unit of heat energy equal to the amount of heat that will raise the temperature of one kilogram of water 1° Centigrade. It is approximately equal to 4 BTUs. (In scientific terminology this is the kilocalorie, 1,000 small calories.)

carbon dioxide (CO_2) — A compound of carbon and oxygen formed whenever carbon is burned.

carbon monoxide (CO) — A compound of carbon and oxygen produced by the incomplete combustion of carbon. It is emitted by automobiles and is the major air pollutant on the basis of weight.

catalytic converter — A device added on the exhaust pipe of an automobile that converts the air pollutants, carbon monoxide (CO) and hydrocarbons, to carbon dioxide (CO_2) and water.

Celsius — See Centigrade.

Centigrade — A temperature scale in which the temperature of melting ice is set at 0°, the temperature of boiling water at 100°. One degree Centigrade is 9/5 of a degree Fahrenheit. The Centigrade scale is sometimes known as the Celsius scale.

char — A porous, solid residue resulting from the incomplete combustion of organic material. If produced from coal, it is called coke, if produced from wood or bone, it is called charcoal. It is more nearly pure carbon than the coal, wood, or bone from which it is produced.

chemical energy — A form of energy stored in the structure of atoms and molecules, and which can be released by a chemical reaction.

classical smog — See sulfur smog.

clean fuel — Usually means fuel in which there is very little sulfur.

coal — A solid, combustible, organic material formed by the decomposition of plant material without free access to air. It is about 75 percent carbon.

coal gas — The volatile, combustible gas driven from coal in coke-making. It has a low energy density, about one-third that of natural gas (also called "fuel gas").

coal gasification — The conversion of coal to a gas suitable for use as a fuel.

coal liquification — The conversion of coal into liquid hydrocarbons and related compounds by hydrogenation, the addition of hydrogen.

coalplex — See combined cycle plant.

coal tar — A gummy, black substance produced as a by-product when coal is distilled.

coke — Degassed coal. A porous, solid residue resulting from the incomplete combustion of coal heated in a closed chamber, or oven, with a limited supply of air. More nearly pure carbon than coal, coke is a desirable fuel in certain industries.

combined cycle electric generating plant — A plant that utilizes waste heat from large gas turbines (driven by gases from the combustion of fuels) to generate steam for conventional steam turbines, thus extracting the maximum amount of useful work from fuel combustion. It may produce fuel (char) as well as electric power.

combustion — Burning. Any very rapid chemical reaction in which heat and light (and sometimes a flame) are produced. Most (but not all) familiar combustions are oxidations — unions with oxygen.

comfort energy — Any form of energy whose end use is the heating and cooling of buildings and homes.

conduction — The transmission of energy directly from molecule to molecule.

convection — The transfer of energy by moving masses of matter, such as the circulation of a liquid or gas.

conversion process — A process by which energy is converted from one form to another, such as radiant energy to heat or electric energy.

cooling towers — Devices for cooling power plants. There are two types: wet towers, in which the warm water is allowed to run over a lattice at the base of a tower and is cooled by evaporation; and dry towers, in which the water runs through a system of cooling fins and is not in contact with the air.

cord of wood — A stack of wood 4 feet by 4 feet by 8 feet. Burned, it produces approximately 5 million Calories of energy.

cracking — Processing that breaks down and rearranges the molecular structure of long hydrocarbon chains in ways that produce lighter hydrocarbons from heavier ones. It is used in the production of volatile fuels, such as gasoline, from crude oil.

crude oil — A mixture of hydrocarbons in liquid form found in natural underground petroleum reservoirs. It is the raw material from which most refined petroleum products are made.

declining block rates — A rate structure in which the charge for energy decreases as the amount consumed increases.

depletion allowance — A Federal tax exemption for a portion of the net income received from producing a natural resource. The amount of the exemption is based on the perceived importance of the energy resource. For oil, gas, and uranium, 22 percent of the income is presently exempted.

deuterium — A hydrogen isotope, the nucleus of which contains one proton and one neutron. (Ordinary hydrogen atoms have only a proton in the nucleus.) About 0.0164 percent of hydrogen occurs naturally as deuterium, which is expected to be the primary fuel for fusion power plants.

distillate oils — Any fuel oil, gas oil, topped crude oil or other petroleum oil derived by refining or processing crude oil or unfinished oils, which has a boiling range at atmospheric pressure from 550 to 1,200°F. Distillate oils account for 25-30 percent of refined petroleum products.

doubling time — The time it takes for a quantity to double.

dry steam — Steam so hot that no water droplets are mixed with it.

efficiency — The efficiency of an energy conversion is the ratio of the useful work or energy output to the work or energy input.

$$E = \frac{\text{work or energy out}}{\text{work or energy in}} \times 100 \text{ percent}$$

electric current — A flow of charged particles, usually electrons (see below).

electron — An elementary particle with a negative charge that orbits the nucleus of an atom. Its mass at rest is approximately 9×10^{-28} gram, and it composes only a tiny fraction of the mass of an atom. Chemical reactions consist of the transfer and rearrangement of electrons between atoms.

electrostatic precipitator — A device that removes the bulk of particulate matter from the exhaust of power plants. Particles are attracted to electrically charged plates and the accumulation can then be washed away.

energy — A quantity having the dimensions of a force times a distance which is conserved in all interactions within a closed system. It exists in many forms and can be converted from one form to another. Common units are Calories, joules, BTUs and kilowatt-hours.

energy density — Energy per unit of weight contained in a fuel.

energy intensiveness (EI) — A measure of energy utilization. For passenger transport, for example, it is a measure of Calories used per passenger mile.

environmental impact statement — Analytical statements that attempt to balance costs and benefits of projects from an environmental as well as economic point of view.

exponential growth — Growth for which the percentage increase for a given time interval is constant. If such growth is plotted on a semilogarithmic graph, in which the vertical axis represents the logarithms of the numbers rather than the numbers themselves, the exponential curve becomes a straight line. A savings account at compound interest is a familiar example.

Fahrenheit — A temperature scale in which the temperature of melting ice is set as 32° and the temperature of boiling water as 212°. One Fahrenheit degree is equal to five-ninths of a Centigrade degree.

fermentation — A process in which carbohydrates are changed to hydrocarbons by the action of microorganisms.

First Law of Thermodynamics — Also called the Law of Conservation of Energy. It states: Energy can neither be created nor destroyed.

fission — The splitting of heavy nuclei into two parts (which are lighter nuclei), with the release of large amounts of energy and one or more neutrons. The emitted neutrons can be absorbed by and initiate fission in other, similar, nearby nuclei, thus producing a chain reaction.

fluidized bed — A furnace design in which the fuel is buoyed up by air or some other gas. It offers advantages in the removal of sulfur during combustion.

force — Intuitively, a "push or pull." Operationally, a non-zero force is defined by the relation $f = ma$ where f is the force, m is the mass, and a is the acceleration of the object. More accurately, the rate of change of momentum of the object.

fossil fuels — Any naturally occurring fuel such as coal, crude oil, or natural gas, formed from the fossil remains of organic materials.

fuel — Any substance that can be burned to produce heat. Sometimes includes materials that can be fissioned in a chain reaction to produce heat.

fuel cell — A device for combining fuel and oxygen in an electrochemical reaction to generate electricity. Chemical energy is converted directly into electric energy without combustion.

fuel gas — See coal gas.

fuel mix — The percentages of various fuels that make up total fuel consumption.

fuel reprocessing — A recycling operation. Fissionable uranium and plutonium are recovered from uranium fuel rods which have undergone intense neutron bombardment in a nuclear reactor.

fusion — The formation of a heavier nucleus from two lighter ones, such as hydrogen isotopes, with an attendant release of energy. The mass of the new, heavier nucleus is less than the combined masses of the original nuclei; the lost mass appears as energy.

gasoline — A refined petroleum distillate composed primarily of light hydrocarbons. Since light hydrocarbons are a relatively small percentage of crude petroleum, most gasoline is produced by refining ("cracking") crude oil. Gasoline has a boiling range at atmospheric pressure from 80 F to 400 F.

generator — A device which produces electric energy from mechanical energy.

geothermal energy — The heat energy in the earth's crust whose source is the earth's molten interior. When this energy occurs as steam, it can be used directly in steam turbines.

gravitational energy — The energy of attraction between two material bodies. Gravitational force is directly proportional to the product of the masses of the two bodies and inversely proportional to the square of the distance between their centers.

greenhouse effect — The warming effect of carbon dioxide, CO_2, in the atmosphere. CO_2 is transparent to incoming sunlight but absorbs and reradiates the infrared (heat) radiation from earth.

Gross National Product (GNP) — A measure of economic activity. GNP is the total market value of all goods and services produced in a country. Depreciation and other allowances for capital consumption are not deducted.

half-life — The half-life of a radioactive element is the time it takes for one-half of a given amount to decay into another element. After two half-lives, one-fourth of the amount remains; after three half-lives, one-eighth remains, etc.

heat — A form of kinetic energy that flows from one body to another because of a temperature difference between them. The effects of heat result from the motion of molecules. Heat is usually measured in Calories or British Thermal Units (BTU).

heat engine — Any device that converts heat energy into mechanical energy.

heat pump — A device that transfers heat from a cooler region to a warmer one by the expenditure of mechanical or electric energy. Heat pumps work on the same general principle as refrigerators and air-conditioners, but are reversible and can pump outside heat in to warm or inside heat out to cool.

heat tax — The heat energy that becomes unavailable for further use whenever energy is converted from one form to another. (See also the Second Law of Thermodynamics.)

heavy water — Water in which all hydrogen atoms have been replaced by deuterium. It is used as a moderator in some nuclear power plants.

high temperature gas reactor (HTGR) — A nuclear reactor which differs from light water reactors in having graphite as a moderator and helium as a coolant. Although not primarily a breeder reactor, thorium 232 can be added to the core and converted into uranium 233 which is a reactor fuel.

horsepower (hp) — A standard unit of power equal to 746 watts.

hydrocarbons — Molecules composed of carbon and hydrogen atoms in various proportions. They are usually derived from living materials.

hydroelectric plant — An electric power plant in which the energy of falling water is converted into electricity by turning a turbine generator.

hydropower — Power produced by falling water.

import quota — Government-set limits on the importation of foreign products.

indirect energy — Any form of energy used in the manufacture of goods or provision of services which themselves may or may not use energy.

intermediate energy forms — Energy in transit from its natural form to the form in which it is useful. For example, energy of coal or falling water (the primary energy form) is converted to electricity (the intermediate form) which in turn is converted to heat energy (the final form) in a radiator.

in situ — In the natural or original position or location. *In situ* production of oil shale, for instance, is an experimental technique in which a region of shale is drilled, fractured, and set on fire. The volatile gases burn off, the oil vaporizes, then condenses and collects at the bottom of the region, from which it can be recovered by a well.

There also has been some experimentation with *in situ* conversion of coal.

ionization — Removal of some or all electrons from an atom, leaving the atom with a positive charge, or the addition of one or more electrons, resulting in a negative charge.

isotope — Any of two or more species of atoms having the same number of protons in the nucleus (or the same atomic number) but with differing numbers of neutrons. All isotopes of an element have the same number of electrons and have identical chemical properties, but the different nuclear masses produce slightly differing physical properties. Since nuclear stability is governed by nuclear mass, one or more isotopes of an element may be radioactive or fissionable, while other isotopes of the same element may be stable. In the usual notation isotopes of the same element are identified by the total of neutrons and protons in the nucleus, for example, uranium 235 and uranium 238.

joule — A metric unit of work or energy; the energy produced by a force of one newton operating through a distance of one meter.

kerosene or kerosine — A mixture of hydrocarbons obtained by the fractional distillation of petroleum and used as a fuel for jet engines and gas turbines. It consists of slightly heavier hydrocarbons than are found in gasoline and naphtha.

kilowatt (kw) — A unit of power, usually used for electric power, equal to 1,000 watts, or to energy consumption at a rate of 1,000 joules per second.

kilowatt-hour (kw-hr) — A unit of work or energy equal to that expended by one kilowatt in one hour. It is equivalent to about 853 Calories of heat energy.

kinetic energy — The energy of motion; the ability of an object to do work because of its motion.

laser — A device that can produce high-intensity, coherent radiation. Coherent radiation or light is produced when the atoms or molecules in a material are forced to radiate at the same time, in step with one another, rather than randomly and independently as in a normal light bulb.

Law of Conservation of Energy — See First Law of Thermodynamics.

life cycle costs — The cost of an item year by year, including initial purchase price as well as cost of operation, maintenance, etc. over the life of the item.

light — Electromagnetic radiation which can affect the eye. The portion of the electromagnetic spectrum considered visible light is wave lengths from approximately 430 millimicrons to 690 millimicrons. (1 millimicron = 10^{-9} meter.)

light water reactor (LWR) — Nuclear reactor in which water is the primary coolant/moderator. They presently use slightly enriched uranium 235 as fuel.

liquid metal fast breeder reactor (LMFBR) — A nuclear breeder reactor cooled by molten sodium in which fission is caused by fast neutrons. It uses uranium 235 or plutonium 239 as fuel and produces additional plutonium 239 from the uranium 238 in a "blanket" around the reactor core.

liquified natural gas (LNG) — Natural gas that has been cooled to approximately −160°C, a temperature at which it is a liquid. Since liquification greatly reduces the volume of the gas, the costs of storage and shipment are reduced.

load factors — The percentage of capacity actually carried. For example, the average number of passengers for a certain size car divided by the passenger capacity of that size car would equal the load factor.

long wall mining — A technique in which an armored mining machine progresses into a seam and allows the ceiling to collapse behind it. This eliminates the necessity of leaving coal behind as pillars, thus substantially increasing the recovery factor.

Lurgi process — A coal gasification process developed in Germany and already in commercial use in Europe. It produces a gas of somewhat lower heat value than natural gas.

magma — Molten rock within the earth's interior.

magnetohydrodynamic (MHD) generator — An expansion engine in which electricity is generated from the combustion of fuels without going through an intermediary steam turbine. Hot, partially ionized gases move through a magnetic field, generating a current that is then collected by electrodes lining the expansion chambers.

marginal cost pricing — The basing of price on the cost of the last unit produced.

mechanical energy — One form of energy. It is observable as the motion of an object.

megawatt (mw) — A unit of power. A megawatt equals 1,000 kilowatts, or 1 million watts.

microwave — Electromagnetic radiation with wavelengths of a few centimeters. It falls between infrared and radio wavelengths on the electromagnetic spectrum.

mine acids — Acids, usually a sulfuric acid formed by the action of water on sulfur left over from coal mining operations.

mine mouth plant — An electric generating plant located at the source of coal and relying on high voltage transmission lines to carry the electricity to distant load areas.

moderator — A material used in a nuclear reactor to slow the speed of neutrons and thus control the rate of fission. Common moderators are graphite, water, deuterium, and beryllium.

molecule — Atoms combined to form the smallest recognizable unit of a substance. For example, the water molecule is composed of two atoms of hydrogen and one atom of oxygen.

natural gas — A naturally occurring mixture of hydrocarbons found in porous geologic formations under the earth's surface, often in association with petroleum. It is almost pure methane, CH_4, but also contains small amounts of various more complex hydrocarbons.

natural gas liquid — Components of natural gas which are liquid at room temperature but become gases at slightly higher temperatures. Propane and butane are examples.

neutron — An elementary particle which is present in all atomic nuclei except for the most common isotope of hydrogen. Its mass is approximately that of a proton, but it has no electric charge. Neutrons are released in fission and fusion reactions.

nuclear energy — The energy released during reactions of atomic nuclei.

nuclear reactor — A device in which a fission chain reaction can be initiated, maintained, and controlled. Its essential component is a core with fissionable fuel. It usually has a moderator, shielding, coolant, and control mechanisms.

nucleus — The extremely dense, positively charged core of an atom. It contains almost the entire mass of an atom, but fills only a tiny fraction of the atomic volume.

"off-peak" power — Power generated during a period of low demand.

oil import quota — See import quota.

oil depletion allowance — See depletion allowance.

oil shale — A sedimentary rock containing a solid organic material called kerogen. When oil shale is heated at high temperatures, the oil is driven out and can be recovered.

once-through cooling — Cooling of an electric generating or industrial plant by pumping cold water from a river or lake through the condenser and then discharging the heated water back into the source.

OPEC — The Organization of Petroleum Exporting Countries. An organization of countries in the Middle East, North Africa, and South America which aims at developing common oil-marketing policies.

overburden — The material (soil, rocks, etc.) that overlies an ore or coal deposit. The overburden is removed in strip mining before the coal or ore is mined.

ozone — A molecule containing three oxygen atoms (O_3). It is formed when solar radiation splits an oxygen (O_2) molecule into two oxygen atoms, one of which then combines with another oxygen molecule. At the top of the earth's atmosphere, it acts as a protective layer by absorbing ultraviolet radiation. It is also a major component of photochemical smog; it has a sharp, unpleasant odor and is an eye irritant.

PANS — Peroxyacetyl nitrates, components of photochemical smog formed by the action of sunlight on the nitrogen oxides and hydrocarbons of air pollution.

paramarginal resource — An identified resource that is not recoverable under current economic or technological conditions.

particulates — The small soot and ash particles produced by burning.

peak load — The maximum amount of power delivered during a stated period of time.

permafrost — The permanently frozen subsoil found in colder areas of the world such as northern Canada and Alaska.

petrochemicals — Chemicals derived from petroleum.

petroleum — (or oil) An oily, flammable liquid that may vary from almost colorless to black and occurs in many places in the upper strata of the earth. It is a complex mixture of hydrocarbons and is the raw material for many products.

photochemical smog — Smog produced by the action of sunlight on the pollutants emitted by automobiles. The major components of photochemical smog are ozone and peroxyacetyl nitrates (PANs).

photons — A quantum (the smallest unit) of electromagnetic radiation. It has no mass or electric charge, but behaves like both a particle and a wave in its interactions with other particles.

photosynthesis — The process by which green plants convert radiant energy (sunlight) into chemical potential energy. Carbon dioxide and water are converted into carbohydrates (such as glucose). Carbon dioxide (CO_2) + water (H_2O) + energy = carbohydrates $C_x(H_2O)Y$ + Oxygen (O_2).

photovoltaic process — The process by which radiant energy is converted directly into electric energy. Solar radiation striking certain materials is absorbed, causing separation of electrons from atoms. The migration of these electrons in one direction and of the positively charged ions in the other produces a small potential difference, typically about 0.5 volts.

plasma — A "gas" of charged particles which exists only at temperatures high enough to strip all electrons from atomic nuclei.

potential energy — "Stored" energy. Energy in any form not associated with motion; such as that stored in chemical or nuclear bonds, or energy associated with the relative position of one body to another.

power — The rate at which work is done or energy expended. It is measured in units of energy per unit of time such as Calories per second, and in units such as watts and horsepower.

primary energy — Energy in its naturally-occurring form — coal, oil, uranium, etc. — before conversion to end-use forms.

productivity — The value added to goods divided by the man-hours input.

proton — An elementary particle present in all atomic nuclei. It has a positive electric charge. Its mass is approximately 1,840 times that of an electron.

pumped storage — Reversible pump-turbines use surplus electric power to lift water into a reservoir when demand is low and then use it to generate power when it is needed.

pyrolysis — The application of high temperature to a substance and the resultant transformation of that substance into one or more other compounds.

radioactivity — The spontaneous transformation of an atomic nucleus during which it changes from one nuclear species to another with the emission of particles and energy.

radon — A radioactive gas which is formed by the decay of uranium and other radioactive materials.

recoverable resource — That portion of a resource expected to be recovered by present-day techniques and under present economic conditions. Includes geologically expected but unconfirmed resources as well as identified reserves.

reserve — That portion of a resource that has been actually discovered and that is presently technically and economically extractable.

residual fuel oil — The heavy residue of petroleum that remains after lower boiling fractions are distilled. It is used primarily for generating electricity in industry and large commercial buildings.

resource — The total estimated amount of a mineral, fuel, or energy source, whether or not discovered or currently technologically or economically extractable.

retorting — The heating of oil shale to drive out the oil and gas.

secondary recovery — Recovery techniques used after some of the oil and gas has been removed and the natural pressure within the reservoir has decreased.

Second Law of Thermodynamics — One of the two "limit laws" which govern the conversion of energy. Referred to here as the "heat tax," it can be stated in several equivalent forms, all of which describe the inevitable passage of some energy from a useful to a less useful form in any energy conversion.

solar cell -- A device which converts radiant energy directly into electric energy by the photovoltaic process. Each cell produces a small potential difference, typically about 0.5 volts; an array of cells can provide a useful electric power capacity.

solar collector — A device for collecting solar energy and converting it into heat.

solar energy — The electromagnetic radiation transmitted by the sun. The earth receives about 4,200 trillion kilowatt-hours per day.

solar farm — Not yet in existence, these "farms" would consist of an array of solar collectors, a heat transfer system, and electric generating facilities.

solvent refined coal (SRC) — A tar-like fuel produced from coal by dissolving it in a solvent. It is higher in energy value and contains less sulfur or ash than coal.

stored energy — See potential energy.

strip mining — A mining technique used when deposits of coal lie relatively near the surface (less than 100 feet). The overburden (the soil and rock above the coal) is stripped away, the coal removed, and the overburden from a trench dumped in the previous, and parallel, one. Strip mining is used primarily for coal, but may be used extensively in the mining of oil shale as well.

submarginal resource — That portion of a resource that cannot presently be extracted economically. As the economic picture and technology change, some submarginal resources may become recoverable resources.

subsidence — A sinking down of a part of the earth's crust due to underground excavations. If extensive, a cave-in can result.

sulfur smog (classical smog) — This smog is composed of smoke particles, sulfur oxides (SO_x), and high humidity (fog). The sulfur oxide (SO_3) reacts with water to form sulfuric acid (H_2SO_4) droplets, the major cause of damage.

supertankers — Extremely large oil tankers that can hold up to 4 million barrels (170 million gallons) of oil. The largest ones will require deepwater ports.

synthetic natural gas (SNG) — A gaseous fuel manufactured from coal. It contains almost pure methane, CH_4, and can be produced by a number of coal gasification schemes. The basic chemical reaction is coal (C) + $2H_2 \rightarrow CH_4 + \text{heat}$.

system efficiency — The cumulative efficiency of a process from the extraction of the natural fuel to the final use.

tar sand — A sandy geologic deposit in which oil is found. The oil binds the sand together.

temperature — Intuitively, the "hotness" or "coldness" of a substance, a measure of the changes which result from heat energy transfer. The temperature of a substance is proportional to the average kinetic energy of its atoms or molecules.

tertiary recovery techniques — Use of heat and other methods to augment oil recovery (presumably occurring after secondary recovery).

thermal energy — Heat energy.

thermal pollution — An increase in water or air temperature which disturbs the ecology of the area. Most often thermal pollution is associated with electric generating plants, which require large amounts of cooling water to remove waste heat.

thermodynamics — The science and study of the relationship between heat and mechanical work.

thermonuclear reaction — A fusion reaction which is initiated by intense heating.

threshold dose — The largest "safe" radiation dosage. Theoretically, no damage would occur below this level. It is not presently possible to determine whether there is a threshold dose or whether any amount of radiation causes some effect.

topping cycle — A means to use high-temperature heat energy that cannot be used in a conventional steam turbine. A gas turbine, for instance, might operate as a topping cycle on furnace gases of 2 000°F and its exhaust could then heat steam for a turbine operating at 1,000°F.

transmission line — A cable or wire through which electric power is moved from electric power generating plants to areas of use by consumers. It usually is operated at greater than 250,000 volts.

tritium — A radioactive isotope of hydrogen in which the nuclei of the hydrogen atoms contain one proton and two neutrons.

tundra — A thin layer of topsoil on top of the permafrost, a permanently frozen subsoil.

turbine — A bladed, wheel-like device which converts the kinetic energy of a gas or liquid into the mechanical energy of a rotating shaft. A motor turned by a stream of fluid or gas under pressure.

ultraviolet radiation — Electromagnetic radiation whose wavelength is somewhat shorter than that for visible light but longer than that for x-rays.

value added — The difference between the value of a delivered product and the cost of the raw materials, labor, and energy to produce it.

voltage — The potential difference measured between two points in an electric circuit. The work per unit charge required to move an electric charge between two points.

water table — The level below the surface at which the ground becomes saturated with water.

watt (w) — A metric unit of power usually used in electric measurements which gives the rate at which work is done or energy expended. One watt equals one joule of work per second.

work — Energy that is transferred from one body to another in such a way that a difference in temperature is not directly involved. The product of an external force times the distance an object moves through its application.

x-ray — Electromagnetic radiation with a very short wavelength (about the diameter of an atom).